



AGRICULTURAL RESEARCH INSTITUTE

PUSA

THE  
JOURNAL  
OF  
THE LINNEAN SOCIETY.

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ZOOLOGY.

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LONDON:

SOLD AT THE SOCIETY'S APARTMENTS, BURLINGTON HOUSE,  
PICCADILLY, W.,

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LONGMANS, GREEN, AND CO.,

AND

WILLIAMS AND NORGATE.

1900-1903.



Dates of Publication of the several Numbers included in this Volume.

No. 179,	pp. 1-105,	published July 31, 1900.
„ 180,	„ 106-160,	„ November 1, 1900.
„ 181,	„ 161-260,	„ April 11, 1901.
„ 182,	„ 261-307,	„ July 15, 1901.
„ 183,	„ 308-365,	„ November 1, 1901.
„ 184,	„ 366-433,	„ April 1, 1902.
„ 185,	„ 434-454,	„ July 1, 1902.
„ 186,	„ 455-532,	„ May 1, 1903.

PRINTED BY TAYLOR AND FRANCIS,

RED LION COURT, FLEET STREET.

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## ERRATA.

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- Page 146, line 9 from top, for *Eriopsis* read *Eriopis*, Brugz.  
„ 285, line 5 from bottom, for *Euromyidæ* read *Eryomyidæ*.  
„ „ line 19 from bottom, for *Eromyidæ* read *Eryomyidæ*.  
„ 322, line 13 from top, for *Philontis fontana* read *Philonotis fontana*,  
Brid.  
„ 366, line 2 from top, for *Phytoptis ribis* read *Phytoptus ribis*, Westw.  
„ 383, line 14 from bottom, for *Nubecularia Bradleyi*, Millett, read  
*Nubecularia Bradyi*, Millett.  
„ 406, line 14 from top, for *Anomalina grosserrugosa* read *Anomalina grosse-*  
*rugosa*, GümbeL.  
„ 413, line 7 from top, for *Vernaculina Davidiana* read *Valculina David-*  
*iana*, Chapin.  
„ 415, line 22 from top, for *Caudenia nitida* read *Candrina nitida*, d'Orb.

# THE JOURNAL

OF

## THE LINNEAN SOCIETY.

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On some New and Interesting Foraminifera from the Funafuti Atoll, Ellice Islands. By FREDERICK CHAPMAN, A.L.S., F.R.M.S.

[Read 21st December, 1899.] \*

(PLATES 1-4.)

THE expeditions dispatched by the Royal Society of London from New South Wales under the direction of Professor W. J. Sollas, and of Professor T. Edgeworth David, for the purpose of making a boring in a typical atoll in the Pacific Ocean, have furnished zoologists and others with some very interesting material for detailed study. In the examination of this material and that of other coral-reefs, one cannot fail to be impressed by the importance of organisms other than corals in forming the great mass of the reef.

Among the groups of organisms which are as active as coral, and even more so, in building up the enormous banks, mounds, and reefs of limestone in coral areas, we may mention the calcareous algæ *Halimeda* and *Lithothamnion* as prominent rock-formers; the first-named often growing in the greatest profusion to the exclusion of almost all else, especially in the lagoon, whilst the latter grows in branching masses which entangle smaller organisms and loose sand, or encrust corals and millepores, often at a considerable depth. A laminated alga allied to *Lithothamnion* is also found growing in nodular form in alternate concentric layers with the foraminifer *Polytrema*; and the condition favourable for this peculiar intergrowth seems to be a sandy area influenced by strong currents. At the surface on the Funafuti Atoll, these nodular intergrowths were found only on the seaward face of the reef.

[\* This paper has been unavoidably delayed in publication.—Ed.]



The Foraminifera, however, constitute the greater proportion of the enormous deposits of sand associated with the reef formation, and which speedily become consolidated into limestone-rock through the chemical changes which so readily take place therein. The most important genera of the Foraminifera which were found in these coral deposits, taken in the relative order of their abundance, are *Amphistegina*, *Heterostegina*, *Polytrema*, *Tinoporus*, *Orbitolites*, *Carpenteria*, *Gypsina*, *Calcarina*, and *Miliolina*. The three first-named are found commonly throughout the material of the reef-boring, in sand and rock alike, always retaining some part of their original structure; by this they can easily be recognized, although the matrix of the rock may have undergone the most marked changes. In the deeper parts of the Atoll-boring, other genera may have been present, for fragments of *Tinoporus* in various stages of decay were seen down to 245 feet, and *Calcarina* to 274 feet from the surface.

Among other active agents in the building of the limestone-reefs may be mentioned the Alcyonarians, Echinoderms, Serpulæ, and the Mollusca.

Through the kindness of Professor Judd, C.B., and the Coral-Reef Committee of the Royal Society, I have been favoured with the opportunity for thoroughly examining, in respect to the group of the Foraminifera, the whole of the materials obtained by the expeditions to Funafuti, which had been sent to the Royal College of Science, London.

The numerous samples from Funafuti have in most cases now been examined, but to do justice to so large a quantity of material some further work is requisite, and it is therefore considered advisable to publish this paper as a first instalment, which deals with the more prominent or larger forms, especially those found adherent to the coral or encrusting other organisms, and intergrowing with them. These larger forms of the Foraminifera do not seem to have received the notice they deserve, for they often constitute a considerable bulk of the consolidated reef, and are rock-builders in the truest sense of the term. That they are often overlooked is due to the fact that they more frequently occur on the rough and encrusted pieces of reef-rock, which are not so systematically collected, probably owing to their presenting little in the way of attractive specimens of corals and other more or less prominent organic remains.

Whilst describing these species of Foraminifera the occasion

is taken to include an account of several new forms; but this does not exhaust the collection in hand, which it is hoped will furnish interesting material for further papers on the same group of animals.

The localities at Funafuti are given in their relative positions around the atoll from N. E. S. to W.

## FORAMINIFERA.

### Family MILIOLIDÆ.

#### Subfamily PENEROPLIDINÆ.

#### PENEROPLIS, *Montfort* [1808].

#### Subgenus novum MONALYSIDIUM.

*Remarks on the Subgenus.*—Test porcellanous, shell-wall very thin; surface usually covered with minute tubercles, sometimes smooth or highly polished and with vertical rows of puncta (not perforations). Segments sub-globose, flattened or elongate, at first arranged in a spiral, afterwards rectilinear. Aperture simple, either a circular inverted orifice or an everted phialine termination.

This subgenus is intended to comprise the long delicate crosier-shaped specimens of which "*Nautilus lituus*," Gmelin, is the type.

These particular forms were represented in the 'Challenger' collections by imperfect specimens, described by Dr. H. B. Brady under the generic name *Peneroplis*. The Funafuti material has yielded some good examples of these forms; and in the light of these it now appears convenient to distinguish the specimens subgenerically at least, on account of their dimorphic character\*, and especially since their apertures differ from the typical cribrate or dendriform orifice of *Peneroplis* proper, or *Spirolina*, and are similar to *Nodosaria* or *Sagrina* of the hyaline group.

It is possible that d'Orbigny's *Nodosaria punctata*† is a fragment of one of the tuberculate forms of *Monalysidium*.

PENEROPLIS (MONALYSIDIUM) SOLLASI, subgen. et sp. nov.  
(Pl. 1. fig. 6.)

Test consisting of a flat coil of sub-oval segments, which afterwards become a straight series with subglobular or slightly compressed chambers. Terminal orifice with a neat everted

\* In the sense employed by Prof. Kitchen Parker.

† See 'Foraminifères' in Sagra's Hist. Cuba, 1839, p. 14, pl. 1. figs. 4, 5.

margin. Surface of test covered with minute tubercles which under a low power resemble perforations. Length  $\frac{1}{4\frac{1}{2}}$  inch (.52 mm.).

The fragmentary specimens recorded and figured by H. B. Brady\* are tuberculate similarly to the above species, but differ considerably in the shape of the chambers and in showing a strong partitional septum on the surface between each segment.

Found in sand from the beach, Avalau Id. (South Id.), Funafuti. Coll. by Prof. Sollas.

*PENEROPLIS (MONALYSIDIUM) POLITA*, sp. nov. (Pl. 1. fig. 5.)

Test imperfect but probably similar in general outline to the foregoing species, with the exception that the segments, especially of the last part of the series, are more irregular in form. The rectilinear portion of the shell (the only part discovered at present) consists of six segments, subcylindrical and irregular; shell-surface highly polished, with vertical rows of minute puncta on each segment, and white. Aperture with an everted margin. Length of portion found  $\frac{1}{3\frac{1}{2}}$  inch (.714 mm.).

From the beach-sand, Avalau Id. (South Id.), Funafuti. Coll. by Prof. Sollas.

### Family ASTORRHIZIDÆ.

#### Subfamily RHABDAMMININÆ.

*SAGENINA* (nom. emend.)†.

(*Sagenella*, Brady [1879].)

*SAGENINA FRONDESCENS* (Brady). (Pl. 1. figs. 1, 2; Pl. 2. figs. 1, 2.)

*Sagenella frondescens*, Brady, 1879, Quart. Journ. Micr. Sci. vol. xix. p. 41, pl. v. fig. 1; Bütschli, 1880, in Bronn, Klassen etc. Thier-Reichs, p. 195, pl. v. fig. 16; Brady, 1884, Report 'Challenger,' vol. ix. p. 278, pl. xxviii. figs. 14 & 15.

Nothing has been done towards extending the somewhat limited range of distribution for this species since Brady described "this singular little organism from the South Pacific." The original localities were the Admiralty Islands, where it was found on calcareous plants and fragments of shells at 16-35 fathoms; and

\* Report 'Challenger,' 1884, vol. ix. pl. xiii. figs. 24 & 25.

† *Sagenina* is here suggested for *Sagenella*, which name has been previously bestowed on a genus of the Polyzoa. See Hall's Nat. Hist. N. York, 1852, vol. ii. p. 172, pl. 40 E. figs. 6 a, b.

off Tongatabu, Friendly Islands, at 18 fathoms. Brady states that the specimens from the latter locality lack distinctive characters; those around Funafuti, not so greatly distant, being in first-rate preservation, may serve to strengthen his identification. Some of the specimens from the Funafuti lagoon found attached to the surface of *Halimeda*-joints are extremely fine and characteristic.

Seeing Dr. Hæckel's statement with regard to the apparently dubious character of some *Astrorhizidæ*, especially *Rhabdammina*, *Rhizammina*, *Sagenella*, etc., that they "may also belong to the arenaceous Keratosa (*Ammoconidæ*)," I have carefully examined the composition of the test of *Sagenina* (*Sagenella*), with the result that there appears sufficient evidence in support of the view taken by Dr. Brady as to its rhizopodal nature. Sections of a *Halimeda*-joint with *Sagenina* attached have been made in a vertical direction; also the test itself has been isolated. These were examined under a high power, and showed this organism to have a finely arenaceous to subchitinous test (that is to say, where finely divided material is wanting, a thin chitinous tube is the result) traversed by minute inosculating canals such as are seen in the other arenaceous rhizopods.

Hæckel describes a form of the Keratosa, namely *Ammoconia sagenella*\*, with regard to which he says: "Very similar to this latter, or even identical with it, may be that form which Brady has figured as *Sagenella frondescens*." In the description of the species, however, the diameter of the separate branchlets is given as 1-2 mm. The average diameter (and it varies but little) of the branchlets of *Sagenina frondescens* is .5 mm. Further, the example of *Ammoconia* figured in the Report is quite unlike *Sagenina* in consisting of a meshwork of tubes standing erect, instead of being adherent at every point. The general finish of the tubes of *Sagenina*, especially at the terminal or apertural points, enables one to see the affinity of this form with other well-known rhizopods, both arenaceous and hyaline, as *Webbina* and the adherent *Ramulina cervicornis*. In one part of the transparent test which I have examined, there is a curious stellate structure reminding one of the fused spiculose base seen in the tissues of Alcyonarians. There is not sufficient evidence, however, to lead one to form any definite conclusion from this peculiarity of structure.

\* Report 'Challenger,' vol. xxxii. pp. 30 & 31, pl. viii. figs. 5A, 5B.

*Sagenina frondescens* is a well-distributed organism around Funafuti and in the lagoon. In places it is quite abundant. In the dredgings made by Prof. David and Mr. Finckh this species was found as follows:—

N. of Pava, 36 fathoms.

Funamanu (Beacon Id.), 150 fathoms; very fine examples.

Tutanga, 200 fathoms (Halligan and Finckh Coll.), occasional.

S. of Funafuti, 30–120 fathoms.

“To” S. of Funafuti, 60 fathoms, common on *Cycloclypeus* and *Halimeda*.

In the lagoon boring it was found at the surface of the lagoon-floor; very rare.

At 21½ feet below floor; very common, and fine examples.

At 50 feet; frequent.

At 62 feet; common.

At 81½ feet; very rare.

## Family LITUOLIDÆ.

### Subfamily LITUOLINÆ.

#### HADDONIA, *Chapman* [1898].

##### HADDONIA TORRESIENSIS, *Chapman*.

*Haddonina Torresiensis*, Chapman, 1898, Journ. (Zool.) Linn. Soc. Lond. vol. xxvi. p. 452, pl. xxviii. figs. 1–5 and woodcut p. 453.

This interesting genus, although but lately discovered in material from Torres Strait, has already been found in great abundance both around Funafuti and in the lagoon.

The large series of specimens now before us shows to some extent the great variety of forms exhibited by this organism. In the first stages of its growth *Haddonina* is depressed and repent, having a coiled series at the commencement or a simple linear-shaped arrangement of segments; in the latter case it somewhat resembles *Bdelloidina*, to which it probably bears some relationship. The test afterwards grows off the surface of attachment, still retaining its *point d'appui*, often continuing in a very erratic line of growth, and sometimes forming several bends and twists nearly at right angles, in one instance curiously resembling a larva of the Geometrine Lepidoptera when feeling the air for a fresh foothold.

The largest specimen met with measures over  $\frac{5}{8}$  inch (about 16 mm.) in length, and was only slightly attached by the aboral end, coming away in the dredge. The organism has

secondarily attached itself a little beyond the middle of the test to an echinoderm spine. This specimen came from Funamanu Id. (Beacon Id.) at 150 fathoms. *H. Torresiensis* was also found in the material from the boring in the lagoon at Funafuti. The specimens are of average size.

In the dredgings made by Prof. David and Mr. Finckh, I have found *H. Torresiensis* as follows:—

N. of Pava, 35 fathoms; a young individual.

Funamanu Id. (Beacon Id.), 150 fathoms; the large specimen previously mentioned.

Tutanga, 200 fathoms (dredged by Messrs. Halligan and Finckh); rather small examples.

S. of Fuafatu, 25 fathoms; a young individual.

S. of Fuafatu, 60 fathoms; a young example attached to *Cycloclypeus Carpenteri* (form B).

S. of Fuafatu, 30–120 fathoms; a much contorted example.

S. of Fuafatu, 119 fathoms; very common on a fragment of Millepore.

“To” S. of Fuafatu, 40 fathoms, bottom fairly hard; a neat specimen torn off the rock.

“To” S. of Fuafatu, 60 fathoms; a neat specimen.

S.S.W. of Fuafutu, 60 fathoms; common on coral rocks.

Two specimens were also obtained from the lagoon-boring at 35½ feet and at 81½ feet below the lagoon-floor.

#### BDELLOIDINA, *Carter* [1877].

BDELLOIDINA AGGREGATA, *Carter*. (Pl. 1. fig. 3, and fig. in text.)

*Bdelloidina aggregata*, Carter, 1877, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 201, pl. xiii. figs. 1–8; Brady, 1884, Report ‘Challenger,’ vol. ix. p. 319, pl. xxxvi. figs. 4–6.

“Test adherent, depressed; consisting of a number of closely-approximated chambers, arranged more or less regularly in a single, simple or branched, linear series, and intercommunicating by a row of pools on each septal face. Segments very short (on the axis of growth) and broad; curved or irregular in outline; subdivided more or less completely by numerous secondary septa. Walls rough externally, interior surface smooth. Aperture porous. Diameter of the adherent patches  $\frac{1}{8}$  inch (4 mm.) or more.” \*

The above species was well and minutely described by

\* Brady, *op. cit.* pp. 319, 320.

Mr. Carter, who drew attention to the porous nature of the shell-wall in this and some other Rhizopods.\*

With regard to the porosity of the shell-wall, it appears to me that Carter conclusively demonstrated the presence of pores in the wall of the test, and although these pores are not regular enough to be denominated tubules, yet they probably serve the same purpose for the sarcodic body. Dr. Brady has suggested that the puncta on the internal surface of *Bdelloidina* may be only superficial depressions. In corroboration of Carter's original idea, it is worth noting a precisely similar structure in the shell-wall of the allied genus *Haddonina*, in which the test is stronger and more inflated, and the structure of the shell-wall greatly emphasized. There the porosity of the shell-wall seems to exist beyond question.

The apertural pores at the distal end in *Bdelloidina* are evidently the terminations of the labyrinthular canals seen in the interior of the shell.

The width of the test is usually  $\frac{1}{8}$  inch (about 4 mm.) and the length slightly more. One example from Funafatu, however, measures as much as  $\frac{1}{2}$  inch (12.5 mm.).

*Bdelloidina* is a genus likely to be overlooked, since its habit is to seek shelter in hollows of shells and coral-rock, creeping over the interior and filling up irregularities in the surface. Its usual colour, moreover, is that of a calcareous sand, for it is composed of little granules (fragments of organisms) or even minute shells, together with occasional sponge-spicules. This fact probably explains its rarity in records of foraminiferal faunas from coral areas.

The only localized specimens of *Bdelloidina aggregata* previously obtained were from the 'Challenger' dredgings in shallow water near the Admiralty Islands on the north coast of Papua, generally adherent to molluscan shells.

A fossil specimen has been recorded as adherent to a Cretaceous Ammonite from Mr. Matthew Wright's cabinet†; a drawing of this was made many years ago which is in the possession of Prof. Rupert Jones. I am enabled by the kindness of Prof. Jones to give a reproduction of this drawing for the first time. (See fig. 1, p. 9.)

In the neighbourhood of Funafuti *Bdelloidina aggregata* is notably restricted to shallow water.

\* Carter, *op. cit.* pp. 202-208.

† See Brady, Rep. Chall. 1884, vol. ix. p. 320.

Near Pava Id., fairly numerous on fragments of Millepore at 63 fathoms.



Fig. 1.—*Bdelloidina aggregata*, Carter from the Chalk of Kent. (From a drawing lent by Prof Rupert Jones of a specimen in the Collection of the late Matthew Wright.)

Funamanu Id. (Beacon Id.), on *Turbinaria*, 50 fathoms (dredged by Prof. David and Mr. Finckh).

S. of Fuafatu Id., in the interior of molluscan shells, 25 fathoms.

"To" S. of Fuafatu Id., 60 fathoms.

#### Family TEXTULARIIDÆ.

##### Subfamily TEXTULARIINÆ.

##### VALVULINA, d'Orbigny [1826].

##### VALVULINA DAVIDIANA, sp. nov. (Pl. 1. fig. 4.)

Test triangular, chambers triserially arranged and forming a more or less equilateral cone; aperture situated in a sub-crescentic depression, with a tooth-like valve projecting across, and sometimes a secondary one nearly meeting from the opposite side. Texture somewhat coarsely arenaceous, composed of calcareous particles; colour white to pale cream. Length  $\frac{1}{25}$  inch (1 mm.).

The above species belongs to the same type as d'Orbigny's *Valvulina triangularis* from the Tertiary beds of the Paris Basin\*. The specimens from Funafuti differ, however, in having

\* Ann. Sci. Nat., vol. vii. 1826, p. 270, No. 1; Modèles, No. 25.



a more decidedly triangular and elongate test, and the oral end less inflated. The valve is more usually tooth-like, rather than a simple flap as in d'Orbigny's specimens.

The elongated examples of *V. Davidiana*, which by the way are rare, may be compared with *V. Oviedoiana* of d'Orbigny\*; the latter, however, differs in the marked concavity of the face of each segment, as seen in the figures of d'Orbigny's Cuban specimens.

*V. Davidiana* is by no means common, being represented in all the samples mentioned below by one or two examples at most.

It was found in the sand of the beach at Avalau Id. (South Id.) and at Fualopa Id. (Gold Id.); in the sand pumped up from the 1st boring (Sollas) "at no great depth"; and it also occurred in the lagoon boring at 21½ feet below the lagoon-floor.

## Family ROTALIIDÆ.

### Subfamily SPIRILLININÆ.

#### SPIRILLINA, *Ehrenberg* [1841].

##### SPIRILLINA SPINIGERA, sp. nov. (Pl. 1. figs. 7 a-c.)

Test free, but perhaps at one time adherent or resting generally on one face, discoidal, consisting of a single tube in four convolutions. The two sides unequal, the broader or basal face concave, having the primordial or central portion globulose and armed with a short blunt spine which does not project beyond the general surface; around the periphery other blunt spines are arranged, to the number of fourteen or more, and the salient edges of the coils are more or less spinose. The upper (smaller) face is slightly convex and tolerably smooth. The terminal portion of the coil is separated from the rest of the shell and is slightly reverted. Diameter of test  $\frac{1}{7}$  inch (.325 mm.).

In having the lateral faces of unequal size this form resembles *Spirillina inequalis*, Brady†.

It also shows some affinity towards *S. tuberculata*, Brady‡, in its separated termination.

The form may have been derived directly from *S. limbata* var.

\* Foram. Cuba, 1839, p. 103, pl. ii. figs. 21, 22 (*V. Oviedoana* on plate).

† Quart. Journ. Micr. Sci. vol. xix. n. s. (1879), p. 278, pl. viii. figs. 25 a, b.

‡ Ibid. p. 279, pl. viii. figs. 28 a, b.

*denticulata*, Brady\*, by the redundant outgrowth of the transverse bars or denticulæ, but this is merely a suggestion.

From beach-sand, Avalau Id. (South Island), Funafuti; very rare. Collected by Prof. Sollas.

Also from the boring in the lagoon at Funafuti at 62 feet below the floor of the lagoon (163 feet below low-water spring tides); very rare.

*SPIRILLINA TUBERCULATO-LIMBATA*, sp. nov. (Pl. 1. figs. 8 *a-c*.)

Test discoidal, consisting of a single tube with about six convolutions. The larger and flat surface is limbate and has the peripheral edge of the coil sharp on that side; the smaller face is slightly rounded and strongly tuberculate. The upper part of the peripheral edge rounded. Diameter  $\frac{1}{50}$  inch (.5 mm.).

The dissimilar faces remind one of *S. inæqualis*, Brady, but in that species the peripheral edge is blunt or square and the smaller face is not so characteristically tuberculate.

*S. tuberculato-limbata*, as its name implies, combines in one form the characters of two of Brady's species, *S. tuberculata*† and *S. limbata*‡.

This species was found at the depth of 40 feet in the 2nd boring at Funafuti (Sollas Coll. 1896), where it was common.

It has occurred sparingly at the depths of 65 and 70 feet in the deep boring at Funafuti (David Coll. 1897). Also in dredgings N. of Pava, 36 fathoms (David Coll. 1898).

#### Subfamily ROTALINÆ.

##### *DISCORBINA*, Parker & Jones [1862].

*DISCORBINA TUBEROCAPITATA*, sp. nov. (Pl. 1. figs. 9 *a-c*.)

The superior aspect roughly conical, the apex swollen into a ball-like prominence; two convolutions of the shell are visible on the apex. The inferior surface is flat or slightly concave, and exhibits five chambers; in the area round the umbilical depression the surface of the shell is granulate. The peripheral edge has a thin and narrow flange. Shell translucent and of a pale opalescent blue colour. Diameter  $\frac{1}{72}$  inch (.347 mm.).

\* Rep. Chall. vol. ix. 1884, p. 632, pl. lxxxv. fig. 17.

† Quart. Journ. Micr. Sci. vol. xix. n. s. 1879, p. 279, pl. viii. figs. 28 *a, b*; Rep. Chall. vol. ix. 1884, p. 631, pl. lxxxv. figs. 12-16.

‡ Quart. Journ. Micr. Sci. vol. xix. n. s. 1879, p. 278, pl. viii. figs. 26 *a, b*; Rep. Chall. vol. ix. 1884, p. 632, pl. lxxxv. figs. 18-21.

This curious little species is quite distinct from the other forms of *Discorbina* found at Funafuti. It appears to have had its origin in a form similar to *D. pileolus*, d'Orbigny\*, which it somewhat resembles in the conical portion—a form common in the shallow waters of the Pacific.

*D. tuberculata* is rare, and has occurred in two samples as far as they have been at present examined. In the deep boring at Funafuti (David, 1897) at a depth of 65 feet; and in the lagoon-boring at 50 feet below the floor of the lagoon.

#### CARPENTERIA, Gray [1858].

CARPENTERIA UTRICULARIS, Carter. (Pl. 2. fig. 4; Pl. 4. figs. 3, 4.)

*Polytrema utriculare*, Carter, 1876, Ann. Mag. Nat. Hist. ser. 4, vol. xvii. p. 210, pl. xiii. figs. 11-16.

*Carpenteria utricularis*, Carter, 1877, Ann. Mag. Nat. Hist. ser. 4, vol. xx. p. 176; Brady, 1884, Report 'Challenger,' vol. ix. p. 678, pl. xcix. figs. 6, 7, pl. c. figs. 1-4; Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii., Abth. ii. p. 246, pl. xxi. fig. 18.

The chief characteristics of this species are the strongly inflated segments, the occasional plurality of apertures (basal as well as terminal), and the coarsely reticulated structure of the walls of the test. In sections the shell-wall is seen to have a papillate (rugose) external surface. The colour of *C. utricularis* in the Funafuti specimens is sometimes brown or ash-grey, but generally speaking the specimens are of a vivid apple-green tint, probably due to the presence of a symbiotic alga in the coarse structure of the test. The apertural portion of the shell is often prolonged into a slender salient tube.

*C. utricularis* is apparently the commonest form of *Carpenteria* dredged at Funafuti.

This species has been recorded from the Pacific, Cape Verde Islands, the West African coast, the Mauritius, and the West Indies. Brady records it at depths ranging from 16 to 350 fathoms. In the samples collected round Funafuti by Prof. David and Mr. Finckh, I have found *C. utricularis* in the following:—

North of Pava, 57 fathoms, on a gorgonid and a millepore.

\* *Valvulina pileolus*, Voyage Amér. Mérid. 1839, vol. v. pt. 5: "Foraminifères," p. 47, pl. i. figs. 15-17.

*Discorbina pileolus* (d'Orbigny), Brady, Rep. Chall. vol. ix. 1884, p. 649, pl. lxxxix. figs. 2-4.

Funamanu Id. (Beacon Id.), 50 fathoms.

Funamanu Id. (Beacon Id.), 80 fathoms; a specimen of bright green colour attached to a gorgonid.

Off Funamanu Id. (Beacon Id.), 150 fathoms; a specimen attached to *Halimeda*.

Tutanga, 94 fathoms; the largest specimen found, measuring nearly half an inch at the base. This is attached to a cylindrical millepore.

Near Tutanga, 136 fathoms.

S. of Fuafatu, 60 fathoms; on *Cycloclypeus Carpenteri*.

S.S.W. of Fuafatu, 60 fathoms; very abundant on a large coral fragment.

S. of Fuafatu, 25 fathoms. (A depressed form very near one of Gray's figures of *C. balaniformis*.)

A single specimen of *C. utricularis* was also found in the sand pumped up (at no great depth) from the 1st boring (Sollas Coll.). In the deep boring (David Coll.) this species was found at 65 feet and at 70 feet.

*CARPENTERIA BALANIFORMIS*, Gray. (Pl. 4. figs. 1, 2.)

*Carpenteria balaniformis*, Gray, 1858, Proc. Zool. Soc. Lond. vol. xxvi. p. 269, figs. 1-4.

*Carpenteria*, Carpenter, 1862, Introd. Foram. pl. xxi. figs. 6-14.

*C. balaniformis*, Gray, Rupert Jones, 1875, in Griffith and Henfrey's Micrographic Dictionary, 3rd ed., vol. ii. pl. 42. fig. 28.

*C. balaniformis*, Gray, Carter, 1877, Ann. Mag. Nat. Hist. ser. 4, vol. xix. pl. xiii. fig. 13.

"*Carpenteria* young specimens, *C. balaniformis*?" Brady, 1884, Report 'Challenger,' vol. ix. p. 677, pl. xcviii. figs. 14, 17.

*C. balaniformis*, Gray, Agassiz, 1888, Three Cruises 'Blake,' vol. ii. p. 168, fig. 514.

*C. balaniformis*, Gray [non Brady], Egger, 1893, Abhandl. Bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii., Abth. ii. p. 246, pl. xxi. figs. 13-15.

The specific characters of *C. balaniformis* are perhaps difficult to define, since the original specimens of Gray appear to possess some of the characters of both *C. monticularis* and *C. utricularis*, Carter. However, the name may be retained for the small, balaniform, depressed, conical and usually smooth *Carpenteria* often found clustering upon the stems of gorgonids and other objects of attachment, where the currents have more or less access to them.

Egger's specimens were dredged off the coast of West Africa. Examples, which may be taken as typical of the species, were

found round Funafuti in a dredging made between 115 and 200 fathoms. They are attached to corals as *Synhelix*? and *Caryophyllia*?, and to a mass of *Serpula*-tubes; on the latter they occur in great abundance (David Coll.).

It also occurs in dredgings made by Messrs. Halligan and Finckh at Tutanga, 200 fathoms. *C. balaniformis* was also found in sand from the bore-hole, Funafuti, at 75 feet; rare (David Coll.).

*CARPENTERIA MONTICULARIS*, Carter. (Pl. 2. fig. 5; Pl. 4. figs. 5, 6.)

*Carpenteria*, Carpenter, 1862, Introd. Foram. pl. xxi. fig. 7.

*Carpenteria monticularis*, Carter, 1877, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 211, pl. xiii. figs. 9-12; idem, ibid., ser. 4, vol. xx. p. 68, and woodcut; Brady, 1884, Report 'Challenger,' vol. ix. p. 677, pl. xcix. figs. 1-5; Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii., Abth. ii. p. 246, pl. xxi. fig. 12.

This species, although so well-known, does not appear to have been found in any great abundance in the localities from which it has been previously recorded. The exceptionally fine specimens figured by Brady came from Zamboanga, Philippine Islands, at 102 fathoms; and he also records it from nine other localities, chiefly in the Pacific and Indian Oceans, at depths varying from 40 to 1035 fathoms, and at the same time notes that these specimens are "for the most part of small size and not so well characterized."

Egger obtained this species from the coast of West Africa and the Mauritius.

The test of this species is of considerable thickness, with smooth surfaces, unlike *C. utricularis*, and the fine tubuli are here and there relieved by coarser tubules, running parallel with them.

The Funafuti specimens are in nearly all examples of a delicate yellowish- or salmon-pink tint. One specimen is coloured a delicate mauve.

In the dredgings made by Prof. David and Mr. Finckh around Funafuti, I have found *C. monticularis* in the following:—

Funamanu Id. (Beacon Id.), 80 fathoms; one specimen.

Tutanga, 86 fathoms; one specimen.

Tutanga, 135 fathoms; one specimen attached to a molluscan shell.

Tutanga, 200 fathoms.

S.S.W. of Fuafatu, 60 fathoms; one specimen.

In the collections made by Prof Sollas at Funafuti *C. monticularis* has occurred in :—

Beach sand, Gold Island; one specimen.

Beach of Creek, Rocky Island; one specimen.

In coral-rock of the 2nd shaft, trial pit, ocean side; frequent.

Under solid platform, seaward face, 3rd shaft, trial pit; common.

In sand at 90 feet in the 1st (Sollas's) boring; one specimen.

The fragmentary tests of this species also occur in great abundance in some of the thin slices of the core from the deep boring at Funafuti carried out by Prof. Edgeworth David. The remains of this species sometimes constitute quite an appreciable amount of the rock.

#### CALCARINA, d'Orbigny [1826].

CALCARINA HISPIDA, Brady, var. PULCHELLA, nov. (Pl. 1. fig. 10.)

"*Calcarina* distinguished by unusual exuberance of spinous outgrowths," Carpenter, 1862, Introd. Foram. p. 217, figs. xxxiii A & B, figs. xxxiv D, E, F, G.

Many of the specimens of *C. hispida* from Funafuti differ considerably from Brady's type-specimens\*. The shell-wall is more delicate, and the spurs are slenderer, with exuberant outgrowths at the extremities, whilst they are decorated with longer spines than usual. This variation gives to the test a light plumose appearance. In point of size the variety equals the type. The specimens which Dr. Carpenter figured were from the Philippines.

*C. hispida* var. *pulchella* occurs with frequency both in the Beach Sand, "South Island" (Avalau Islet), and in the 1st boring at Funafuti, "at no great depth" (Sollas, 1896).

#### Subfamily TINOPORINÆ.

##### POLYTREMA, Risso [1826].

[The members of this genus are often so like minute branching corals and polyzoa, and in one instance resembling externally certain calcareous algæ, that even at the present time they may

\* *Calcarina hispida*, Brady, 1876, Proc. R. Irish Acad. ser. 2, vol. ii. p. 590.

*C. calcar*, d'Orb., var. *hispida*, Brady, Carter, 1880, Ann. Mag. Nat. Hist. ser. 5, vol. vi. p. 453.

*C. hispida*, Brady, 1884, Rep. Chall. vol. ix. p. 713, pl. cviii. figs. 8, 9.

at first sight be referred to the above groups by those who are not intimately acquainted with the minute structure of these Rhizopods. *Polytrema miniaceum* and its varieties are extremely ubiquitous at Funafuti.]

*POLYTREMA MINIACEUM* (Pallas). (Pl. 4. fig. 7.)

*Millepora miniacea*, Pallas, 1766, Elenchus Zoophytorum, p. 251  
Linné, 1788, Systema Nat., 13th (Gmelin's) ed. vol. i. pt. 6, p. 3784, no. 6;  
Esper, 1791, Die Pflanzenthier, pt. i. p. 225, pl. xvii. figs. 1-4.

*M. rubra*, Lamarck, 1816, Anim. sans Vertèbres, vol. ii. p. 202.

*Polytrema corallina*, Risso, 1826, Hist. Nat. Europ. Mérid. vol. v. p. 340, no. 19.

*P. miniaceum* (Esper), DeFrance, 1816-1830, Dict. Sci. Nat. Atlas, Zooph. pl. xlv. figs. 4, 4a; Blainville, 1826, Dict. Sci. Nat. vol. xlii., Atlas Zooph. vol. i. p. 17; idem, 1834, Actinologie, pp. 410, 673, pl. lxix. figs. 4, 4a.

*P. rubra* (Lam.), Dujardin, 1841, Hist. Nat. Zooph. Infus. p. 259.

*Pustularia rosea*, Gray, 1858, Proc. Zool. Soc. Lond. vol. xxvi. p. 271.

*Polytrema rubra* (Lam.), Carpenter, 1862, Introd. Foram. p. 235, pl. xiii. figs. 18-20.

*P. miniaceum* (Linné), Schultze, 1863, Wiegmann's Archiv, p. 81, pl. viii.; Allman, 1870, Ann. Mag. Nat. Hist. ser. 4, vol. v. p. 372.

*P. miniaceum*, Blainville, Carter, 1876, Ann. Mag. Nat. Hist. ser. 4, vol. xvii. p. 185, pl. xiii. figs. 1-6.

*P. rubra* (Lam.), Schwager, 1877, Boll. R. Com. Geol. Ital. vol. viii. p. 26, pl. 72.

*P. miniaceum*, Blainville, Möbius, 1880, Beitr. Meeresfauna Insel Mauritius etc. p. 85, pl. vii. figs. 1-17; Bütschli, 1880, in Bronn, Klassen etc. Thier-Reichs, p. 208, pl. ix. fig. 11.

*P. miniaceum* (Linné), Brady, 1884, Rep. Chall. vol. ix. p. 721, pl. c. figs. 5-9, pl. ci. fig. 1; Agassiz, 1888, Three Cruises 'Blake,' pt. ii. p. 169, fig. 519; Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii., Abth. ii. p. 437, pl. xxi. figs. 1, 2, 16, 17; Goës, 1896, Bull. Mus. Comp. Zool. vol. xxix. no. 1, Memoir xx. p. 75

*P. miniaceum* occurs in the samples both from the lagoon and the outer part of the reef at Funafuti, as well as from the deeper soundings round about, down to 200 fms. The species is not so common in the lagoon as it is outside the reef, but nevertheless some very fine specimens have been noticed from the lagoon-deposits.

In all cases the specimens were originally attached to some object for basal support; and it is noteworthy that the kind of support has greatly determined the mode of habit of the form, and hence its variations. Where the organism has sufficient space and freedom around its base, the delicate arborescent form

is the result. Should it become cramped in its surroundings, the rhizopod makes a thick base with short and strong prolongations. When the *Polytrema* affixes itself to a detached fragment affected by currents which roll it over, the organism forms a thin encrustation, which in many cases is in turn encrusted by a *Lithothamnion*, then again by *Polytrema*, and so on, until the nodules often measure as much as 5 centimetres in diameter. This latter mode of growth in *Polytrema* has hitherto been unnoticed, and seems to merit a distinct varietal name\*. An intermediate stage between this encrusting *Polytrema* and the arborescent typical form is represented by Carter's *P. mesentericum*†.

The red colour of *Polytrema* is apparently very little, if at all, dependent upon the influence of light. Some of the finest coloured specimens occur at considerable depths, and it is remarkable that off Funamanu Id. (Beacon Island), at a depth of 150 fathoms, *Polytremata* of the deepest and richest colour were found.

Although commonly found in shallower water, *P. miniacum* has been recorded in the 'Challenger' soundings from a depth as great as 1000 fathoms. Egger found it ranging down to a depth of 411 metres (224 fathoms) near Mauritius. Specimens recorded from the Caribbean Sea by Goës were found at 115 fathoms.

POLYTREMA MINIACEUM (*Pallas*), var. INVOLVA, nov. (Pl. 2. fig. 3, & text-fig. 2.)

Test consisting of a rudely parallel series of acervuline chamberlets disposed round a nucleus, or partly encrusting an adventitious particle. The organism in this stage shows little tendency to send forth prolongations, but seems content with forming mere rounded prominences or papillæ at intervals on the surface of growth. This variety often shows a remarkable tendency to alternate in its growth with layers of *Lithothamnion*, thus building up nodular masses of a composite nature‡. The nodules sometimes reach the dimension of 5 centimetres.

As previously noticed, the form named *Polytrema mesentericum*, Carter, may be in part comparable with this form. It is probable, however, that this was the basal portion of a large

\* See p. 1.

† Ann. Mag. Nat. Hist. ser. 5, vol. v. (1880) p. 444, pl. xviii. figs. 3 a-b.

‡ Another species has been noticed at Funafuti which occurs in the limestones alternating in its growth with *Lithothamnion*, namely *Gypsina inkerens* (Schultze); but it does not form anything like so complete an investment as *P. miniacum* var. *involuta*.



specimen of *Polytrema* often seen adherent to coral-rock, where the test has formed a meandering surface-growth rather than an arborescent structure.



Fig. 2.—Core from boring, Funafuti Atoll, at 766 ft. Containing nodules of *Polytrema miniaceum* var. *involuta* nov. Nat. size.

*P. miniaceum* var. *involuta* occurs in the coarse beach-sand of the outer reef-slope at Funafuti, and also at various depths in the deep boring. Its occurrence in the latter is of very great interest. These nodules of intergrowth are scattered throughout the more sandy parts of the cores of limestone down to a depth of 640 feet, when they are more frequent and of larger development. The largest and most typical specimens come from about 660 feet, where they are embedded in an *Amphistegina*-sand. They are common in the cores down to about 790 feet, after that occurring occasionally, and usually forming smaller nodules.

*P. miniaceum* var. *involuta* has also recently been noticed by the author in the Tertiary limestones of Christmas Island, associated with *Orbitoides*.

#### Family NUMMULINIDÆ.

##### Subfamily NUMMULITINÆ.

##### HETEROSTEGINA, d'Orbigny [1826].

HETEROSTEGINA DEPRESSA, d'Orbigny. (Pl. 3. figs. 6 & 7.)

*Heterostegina depressa*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 305, pl. xvii. figs. 5-7; Modèle, no. 99.

*H. antillarum*, d'Orbigny, 1859, Foram. Cuba, p. 211, pl. vii. figs. 24, 25.

*H. simplex*, d'Orbigny, 1846, Foram. foss. Vienne, p. 211, pl. xii. figs. 12-14.

*H. helvetica*, Kaufmann, 1867, Geol. Beschreib. des Pilatus, p. 153, pl. ix. figs. 6-10.

*H. depressa*, var. *simplex*, d'Orbigny, Goës, 1882, Retic. Rhizop. Caribb. Sea, K. Svenska Vet.-Akad. Handl. vol. xix. no. 4, p. 117, pl. viii. fig. 303.

*H. depressa*, d'Orbigny; Brady, 1884, Rep. 'Chall.' vol. ix. p. 746, pl. cxii. figs. 14-20; Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. Bd. xviii. Abth. ii. p. 241, pl. xx. figs. 34, 35; Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix. no. 2, Memoir xx. p. 79.

As Dr. H. B. Brady has already pointed out in his monograph on the 'Challenger' Foraminifera \*, *H. depressa* can be arranged in two series according to their form and external characters. After a careful study of the Funafuti specimens, I have been able to identify these two series with the dimorphic forms A and B respectively. The megalospheric form (A) embraces the involute, bi-convex type, with the asymmetric (spiral) flange; whilst the microspheric form (B) is represented by the compressed and explanate specimens. The difference between the primordial spheres of the two forms is not very great, but it is constant, their diameters being in the ratio of 3:2.

The megalospheric form is far more common than the microspheric, for in most samples it is in the proportion of about 500 to 1, or even greater.

The megalospheric form in *H. depressa* attains a larger diameter in full-grown specimens than the microspheric, which is unusual amongst the Foraminifera yet examined with regard to dimorphism, but nevertheless instances are known: for example, in *Adelosina polygonia*, Schlumberger, the megalospheric shell is slightly larger than the microspheric (1.5 to 1.4 mm.).

From so large a collection of specimens as we are now dealing with, possibly one of the most extensive from any particular locality, one may obtain a very complete idea of the extent of variation in a species from a given area. *H. depressa* in its megalospheric form varies greatly as to size and thickness, and the microspheric form varies curiously in its internal septal arrangement, to be noticed below. The two forms, however, are in themselves so distinct as to present little difficulty in relegating them to either series.

Form B has a thin and transparent, or translucent, shell-wall, and thus the septation can be clearly seen. The earlier portion shows no secondary septation dividing the chambers into chamber-

\* Rep. Chall. vol. ix. p. 746, pl. cxii. figs 17, 18 19, 20.

lets; but after two whorls of the shell have been completed, and while the test is still small, rudimentary secondary septation begins at the peripheral angles of the chambers, after the manner of d'Orbigny's *Heterostegina simplex* \*. The next stage in the septal division is seen after the completion of about four whorls, when straight, bar-like, but incomplete cross-septa are seen projecting from the septum proper, but which do not extend for more than  $\frac{2}{3}$  across the chamber-cavity. In many specimens this incomplete septation is apparent to within the last few chambers, when it takes on the usual characteristic secondary septation of the Heterostegine type.

One specimen of the complanate type (B) from Funafuti exhibits a remarkable variation in having the secondary chamberlets themselves divided at right angles by a third series of septal bars.

The surface of the shell in this form (B) is usually granulate, or covered more or less with numerous hyaline papillæ, which are the rounded bases of cones of non-tubulous shell-substance, their points being directed inwards to the median plane. When the granules are arranged, as is sometimes the case, along the septal lines, we have the variation named by d'Orbigny *H. costata* †.

Form A, on the contrary, always possesses a smooth-surfaced shell.

Form B is found most frequently at a depth of 60 fathoms round Funafuti.

In the sarcode of a megalospheric form, which was stained with picrocarmine, a nucleus with a nucleolus was observed, measuring  $70 \times 60 \mu$ .

A microspheric specimen contained, in the middle of the sarcode body, a group of about a dozen rounded particles, probably nutritive; whilst scattered through the body-substance there were seen six or more rounded algal cells (? symbiotic).

*H. depressa* is not confined to the outer side of Funafuti. It is equally common in the lagoon, where it often attains as large dimensions as specimens from the outside. Very large specimens have also been noticed in some of the deeper cores of the boring in the atoll. It is especially noteworthy that the largest specimens of *H. depressa* found at Funafuti, measuring nearly  $\frac{1}{2}$  inch in diameter, were from dredgings at 32 and 36 fathoms outside Funafuti Atoll, N. of Pava (coll. by Prof. David).

\* D'Orbigny's figures, however, appear to belong to form A.

† Foram. Foss. Vienne, 1846, p. 212, pl. xii. figs. 15-17.

## Subfamily CYCLOCYPEINÆ.

CYCLOCYPEUS, *Carpenter* [1856].

This genus is very restricted in its distribution. It appears to find its most congenial habitat in tropical areas where the water is practically free from suspended terrigenous material.

From the investigations made round Funafuti we have learned of the remarkable and perhaps unique abundance of the various stages of this hitherto rare type. In point of fact only two other localities seem to have produced the larger form of *C. Carpenteri*, Brady, which often attains a diameter of  $2\frac{1}{2}$  inches and merits the distinction of being the largest living foraminifer.

The study of the Funafuti specimens at first presented no slight difficulty on account of the occurrence of so many apparently distinct varieties in the material examined. This, however, was cleared away by the discovery of the interesting fact that the whole of the series illustrates different phases or stages of one species, which is dimorphic\*.

In the course of obtaining additional knowledge regarding the coupling of species hitherto considered distinct, it seems most desirable to adhere to the principle of priority in the nomenclature of such dual forms, retaining the earlier of the two names for the pair. For example, in the following pages under the description of the Funafuti specimens of *Cyclocypeus*, two already described species are included in one specific type as the two stages of that species; namely, *C. Guembelianus* and *C. Carpenteri*, the former representing the young of form A, the latter appearing to include forms A and B. The latter species was not named by Carpenter, who figured, however, a large megalospheric specimen (A), whilst he described the exceptionally large examples from Borneo which are now seen to be the adults of form B. With regard to the name which the recent *Cyclocypeus* should now bear, the rule of priority in any case must be considered; but in this it curiously happens that both species date from 1881, and since Carpenter figured both forms A and B, we may therefore keep the name by which Brady designated Carpenter's original specimens, namely *C. Carpenteri*.

The recent *Cyclocypei* are limited to the station off Borneo, where they were dredged from a considerable depth by Capt. Sir

\* In the sense employed by Munier-Chalmas and Schlumberger.

Edward Belcher; also from Kandavu, Fiji, 210 fathoms, form B (in the British Museum, Natural History, labelled *C. Carpenteri* in Dr. H. B. Brady's handwriting); from Mauritius (specimens of form A found by the Author, through the kind offices of Prof. Jeffrey Bell, on a *Turbinaria* in the British Museum); and from the Solomon Islands, amongst specimens which Capt. Guppy had sent Sir John Murray \* (a specimen of form A). There is also an irregular, annulate variety in the British Museum, probably of *C. Carpenteri* (form A), from the Macclesfield Bank, China Sea, 30 fathoms.

The genus *Cycloclypeus* is also represented as fossils in the Tertiary limestones of early date on the S.E. coast of Arabia (*Carter*); from the Tertiaries of Java (*Martin*); and from similar rocks in Borneo (*Newton & Holland*).

*CYCLOCLYPEUS CARPENTERI*, *Brady*. (Pl. 2. figs. 6, 7; Pl. 3. figs. 1-5.)

#### *Form A.*

*Cycloclypeus*, Carpenter, 1856, Phil. Trans. vol. cxlvi. p. 155, pl. xxx. figs. 1 & 3; idem, 1862, Introd. Study Foram. p. 292, pl. xix. fig. 2.

*C. Guembelianus*, Brady, 1881, Quart. Journ. Micr. Sci., n. s., vol. xxi. p. 66 (young form); idem, 1884, Rep. Chall. vol. ix. p. 751, pl. cxi. figs. 8a, b (young form).

*C. Carpenteri*, Brady, Lister, 1895, Phil. Trans. vol. 186B. pp. 437, 438, pl. ix. figs. 52-54.

*C. Guembelianus*, Brady, Verbeek and Fennema, Descr. géol. Java et Madoura, vol. i. pl. ix. fig. 127.

#### *Form B.*

*Cycloclypeus*, Carpenter, 1852, Phil. Trans. vol. cxlvi. p. 555; idem, 1862, Introd. Study Foram. p. 292.

*C. Carpenteri*, Brady, 1881, Quart. Journ. Micr. Sci., n. s., vol. xxi. p. 67; idem, 1884, Rep. Chall. vol. ix. p. 751; Martin, 1896, Jaarb. Mij. Ned. Oost-Ind. pp. 53, 54.

The series of specimens, which, from a biological standpoint, is referable to one species, consists of two dimorphic types, each represented by immature and adult specimens, with here and there some gradational links. It is a significant fact, which asserted itself during the examination of the specimens from Funafuti, and is borne out by material from other localities, that the young and the adult stages of the shell in each form, A and

\* To whom the author is indebted for the opportunity of examining these and other specimens at the 'Challenger' Office.

B, are much more numerous than the specimens which link them together in the intermediate stages of growth; and this seems to be further corroborated by the internal shell-structure, which shows an apparent resting-stage in the shell-development, bounded by an irregular periphery, which differs from the broken and subsequently repaired rings of chamberlets.

*Description* \*:—

FORM A (megalospheric form).—Test discoidal, outline circular, or nearly so; the central area umbonate or biconvex, in full-grown specimens occupying about one-third the entire diameter of the shell. The initial series of chamberlets are enclosed in a secondary growth of shell-substance which gives rise to the umbonate shape of the central area of the disc. Beyond the central thickened area the annuli of the chamberlets are thin and compressed, forming a broad flange around the centre. For the first two or three annuli the chamberlets are approximately square, or even laterally elongated, but they subsequently become more radially elongated, not to so great an extent, however, as in the micro-spheric form next described.

Diameter of test  $\frac{1}{8}$  inch to  $\frac{7}{8}$  inch.

The megalosphere of a typical specimen of form A from Funafuti measured  $260 \times 240 \mu$ . It is ovate, with one end pointed and the other rounded, and it lies in the concave sides of two crescent-shaped chambers, following upon which are the annuli of small chamberlets †.

The nucleus observed by Lister was seen in one case to occupy the megalosphere, and in another it was found in the second chamber; that in the megalosphere was of an oval shape, measuring  $60 \times 40 \mu$ , whilst the nucleus seen in the second chamber was nearly spherical, measuring about  $85 \mu$  in diameter. In the specimens from Funafuti which I decalcified and stained with picro-carminé no nucleus was observed in the central area of the disc, but irregular and ovoid nuclear bodies were seen in the last series of annuli, in many cases extending through an adjacent chamber. The structure of the nucleus was somewhat granulate with darker enclosures, like those observed by Lister.

\* Dr. Brady's description of the young of form A (= *C. Guembelianus*, Brady) now applies to the central area of the disc of full-grown specimens of the megalospheric type. See p. 751, Rep. Chall., vol. ix. 1884.

† See also Lister, *op. cit.* p. 438.

FORM B (microspheric form).—Test discoidal, outline circular; in young individuals very thin, and with the surface granulate. The central area in young and middle-sized specimens is occupied by a small boss, about one-half the diameter of that in the megalospheric form; after the test has attained the diameter of about 15 mm., this central prominence is soon levelled over, since at that period the animal thickens its superficial shell-layer, and covers over any irregularity of surface, including the papillate ends of the non-tubulous cones of the shell-wall.

Diameter of test  $\frac{1}{32}$  to  $2\frac{1}{2}$  inches.

In *C. Carpenteri*, especially in the microspheric form (B), the concentric rings of chamberlets are frequently incomplete owing to the fracture of the periphery during the growth of the animal, which repairs the edge at first by a series of chamberlets parallel with the broken edge, the length of each chamberlet being in succeeding annuli of increasing proportion in the parts requiring more material to bring the contour of the disc back again to its circular form. In this ability to repair the fracture, to which it is so liable on account of its form and thinness, it resembles *Orbitolites* in the porcellaneous group, and especially *O. tenuissima*, Carpenter, who has already pointed out \* that this phenomenon is commoner in the genus *Cycloclypeus* than in *Orbitolites*.

The microsphere of a typical specimen of form B from Funafuti measured 140  $\mu$  in diameter.

It is difficult to obtain specimens of the full-grown microspheric form which show the central chamber intact, for in nearly all cases the median area, containing the sarcode, has been cleared away by a species of *Cliona*.

*Distribution around Funafuti, and in other localities in the Pacific.*—The general geological and geographical distribution of *Cycloclypeus* has been already given (see *antea*, pp. 21, 22).

*Cycloclypeus Carpenteri* has never yet occurred in the lagoon dredgings, although nearly all the other genera of Foraminifera found at Funafuti have been found irrespectively inside the lagoon and on the outer side of the reef.

The depths at which *Cycloclypeus* has been found in the dredgings made by Messrs. Halligan and Finckh are as follows:—

The young of both forms (A and B) from 30–200 fathoms.

The fully-developed form of A from 30–200 fathoms.

The fully-grown microspheric form of B from 46–200 fathoms.

\* Phil. Trans. vol. cxlvi. (1856) p. 556.

At a depth of from 50-60 fathoms large quantities of both A and B were dredged in equal proportion.

The immature stage of form A is common in some dredgings around Funafuti, where the form B is sometimes entirely absent. This small form, the original of Dr. Brady's *C. Guembelianus*, is seen to graduate into the larger forms of the same type, which when fully-grown attain a diameter of  $\frac{7}{8}$  inch (11 mm.). These fully-grown specimens had not been observed by Brady in the 'Challenger' collection, for he remarked \* :—"Notwithstanding their minute dimensions in comparison with the only other recent species hitherto obtained, they are to all appearances fully grown."

Brady, however, appears to have seen the adult specimens later, since there are some examples in the Brady collection at the British Museum (Natural History) of this type, probably obtained by him on his visit to Fiji.

The larger of those specimens examined by Lister appears to be a fully-grown individual of the form A; these were obtained from the S.E. of Nomuka in the Tonga Islands, at a depth of 20-40 fathoms. The young of form A (= *C. Guembelianus*) was recorded in vol. ix. of the 'Challenger' Reports † from Station 174 C, off Kandavu, Fiji Islands, at 210 fathoms. In the 'Summary of Results,' however, the record reads "Station 172 A, off Tongatabu, at 240 fathoms" ‡.

The various records for *Cycloclypeus Carpenteri* around Funafuti are as follows, the localities being taken in rotation N. E. S. & W. :—

*North of Pava Id.*—At depths varying from 36 to 63 fms. At 36 fathoms examples of *Cycloclypeus* consisted chiefly of the immature forms of the megalospheric type. A specimen (adult form A) from 63 fathoms is partially enclosed in an encrustation of *Lithothamnion*—an illustration of the consolidation of reefs by the intergrowth and overgrowth of organisms.

*Off Funamanu Id. (Beacon Id.)*.—Form A occurs at 50 fathoms, very common, especially the young form; at 80 fathoms there were very large examples of form B, encrusted with Polyzoa, and with *Carpenteria* and other adherent Foraminifera; and at 150 fathoms good typical examples, fully developed, of form A.

\* Rep. 'Challenger,' vol. ix. p. 751.

† Pp. 92, 93, & 752.

‡ Summary of Results, 1st part, p. 631.



*S.W. end of Funafuti*.—At 45–51 fathoms, “a bottom of hard rock” (label on specimen). The tests are here stained a dark rich green in the central area, due to the presence of algæ in the chamberlets.

*Off Tutanga Id.*—Form A occurred at 35, 41, and 46 fathoms (at 41 fathoms numerous specimens of both forms were found resting on pink *Lithothamnion* in their places of actual growth); at 50–60 fathoms in association with form B; and at 200 fathoms. Form B was obtained at 46 fathoms; at 50–60 fathoms in association with form A, both very abundant; at 135 fathoms, common; and at 200 fathoms in a pteropod ooze, in association with the form A and at all stages of growth.

*Off Funafatu*.—Form A, 30–120 fathoms, common; at 40 fathoms the specimens are stained, especially towards the central area, with a dark green (? symbiotic) algæ; at 60 fathoms, common. Form B, at 60 fathoms, common; at 119 fathoms, a fragment.

The work of describing these specimens has been mainly carried out in the Geol. Division of the Royal College of Science, to which Institution the collections have been sent. All recent specimens described in this paper will be eventually placed in the British Museum (Natural History).

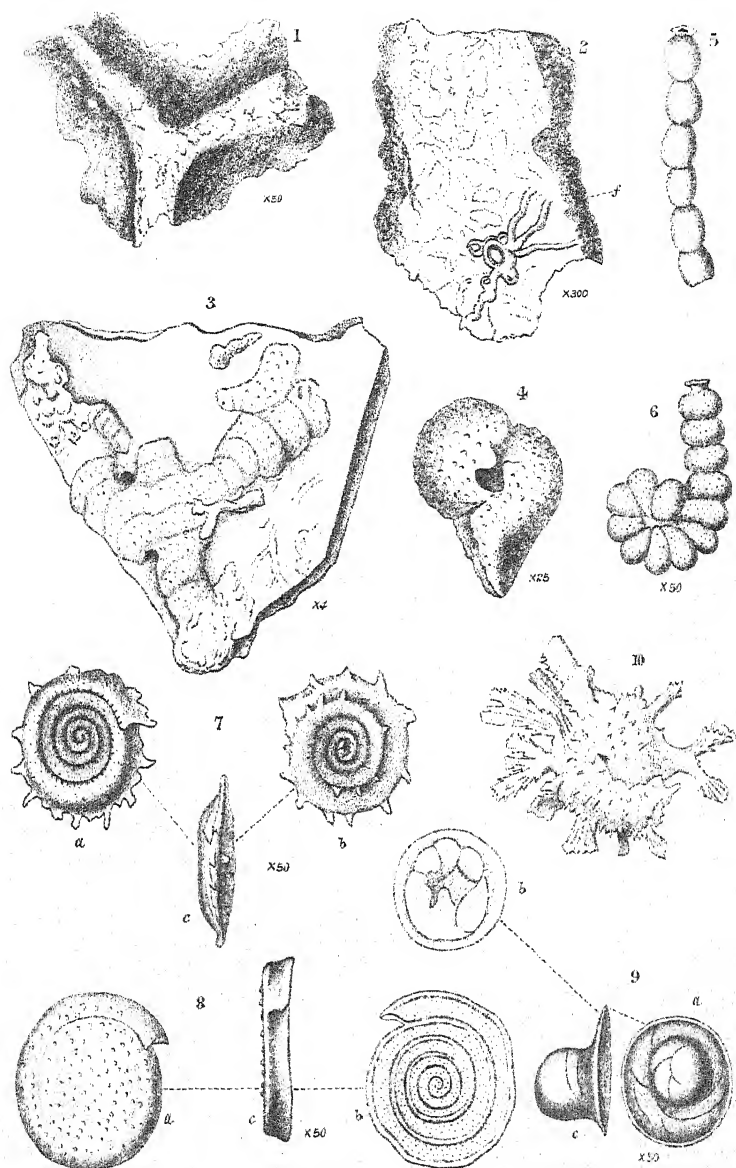
#### EXPLANATION OF THE PLATES.

##### PLATE 1.

- Fig. 1. *Sagenella frondescens*, Brady. A fragment of the branching test, detached, and viewed by transmitted light. The wall of the test over the sarcode-cavity is perforated by thread-like boring algæ.  $\times 50$ .
2. *S. frondescens*, Brady. A fragment of the central area of the wall more highly magnified, exhibiting a reticulate character, and with a boring algæ at f.  $\times 300$ .
3. *Bdelloidina aggregata*, Carter.  $\times 4$ .
4. *Valvulina Davidiana*, sp. nov.  $\times 25$ .
5. *Peneroplis (Monalysidium) polita*, subgen. et sp. nov.  $\times 50$ .
6. “ “ *Sollasi*, “ “  $\times 50$ .
- 7 a-c. *Spirillina spinigera*, sp. nov.  $\times 50$ .
- 8 a-c. “ *tuberculato-limbata*, sp. nov.  $\times 50$ .
- 9 a-c. *Discorbina tuberocapitata*, sp. nov.  $\times 50$ .
10. *Culcarina hispida*, Brady, var. *pulchella*, nov.  $\times 18$ .

##### PLATE 2.

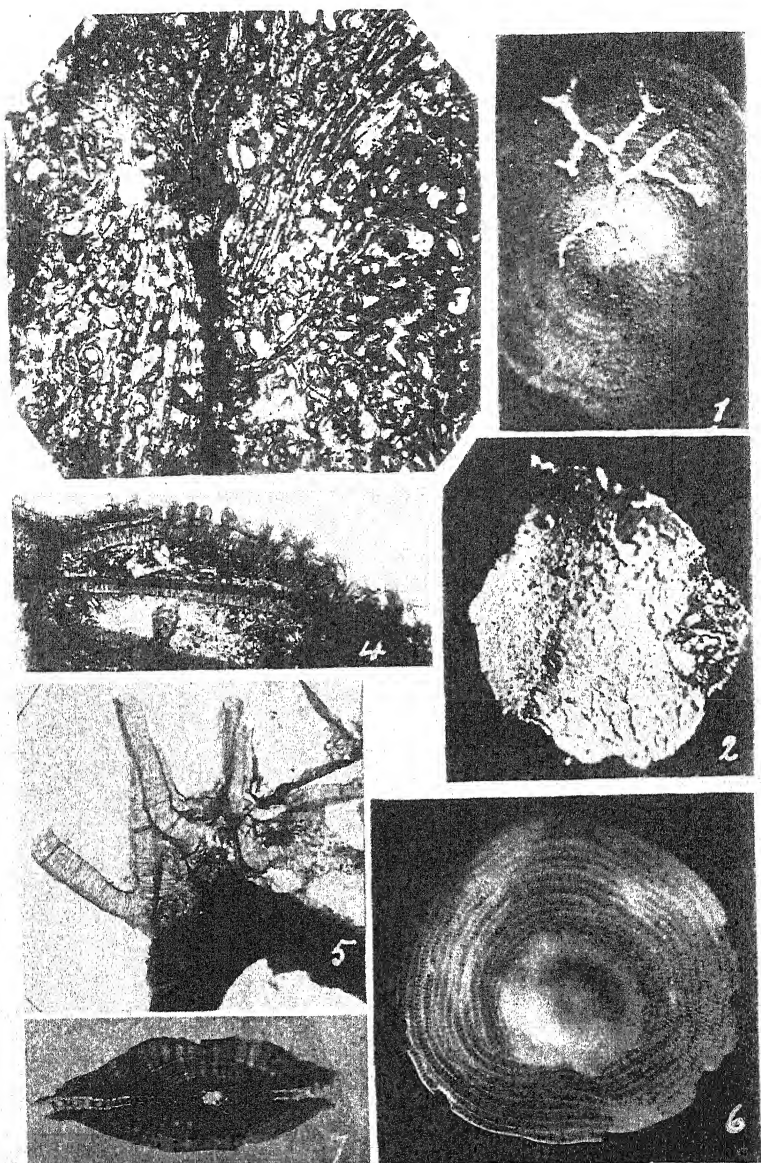
- Fig. 1. *Sagenella frondescens*, Brady, attached to test of *Cycloclypeus Carpenteri* Brady.  $\times 5$ .
2. A prolific growth of *Sagenella frondescens* attached to a large specimen of the microspheric form of *C. Carpenteri*.  $\times 2$ .



F. Chapman ad nat. del.  
M. P. Parker lith.

Geo. West & Sons imp.



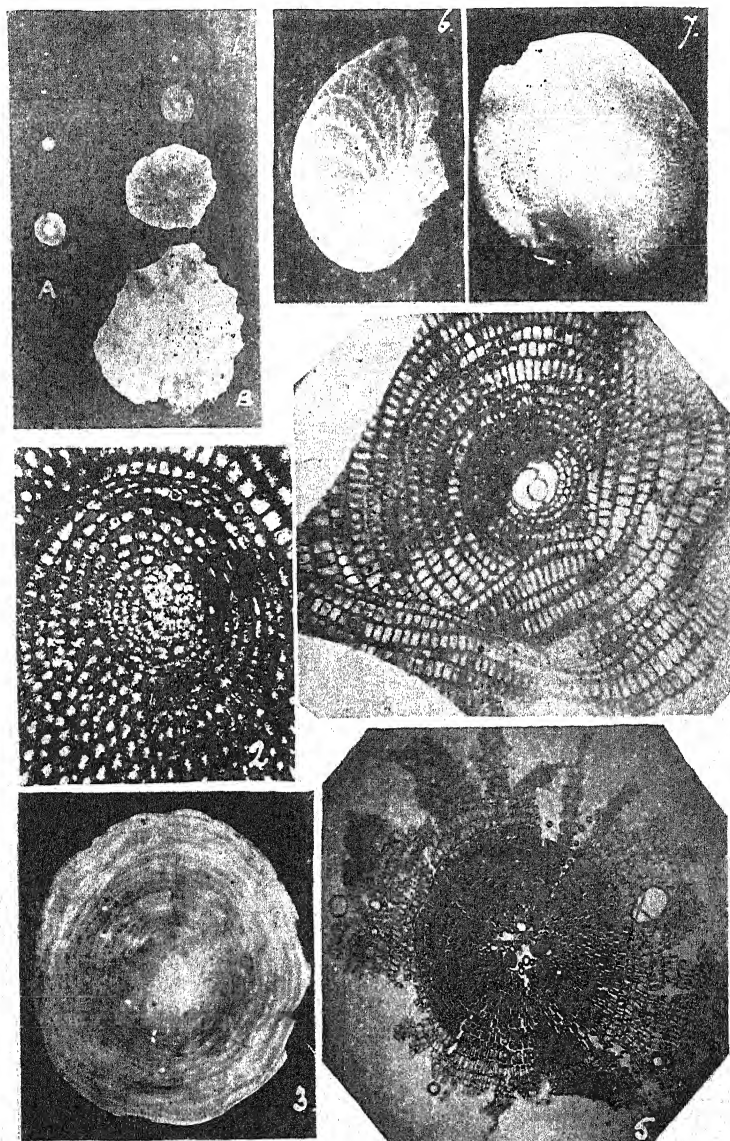


F. C. Photomicro.

Collo. by Morgan & Kidd, Richmond, S.W.

SAGENINA, CARPENTERIA, POLYTREMA AND CYCLOCLYPEUS  
FROM FUNAFUTI.



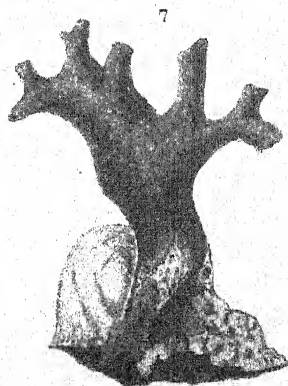
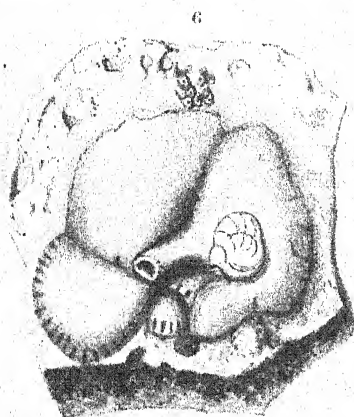
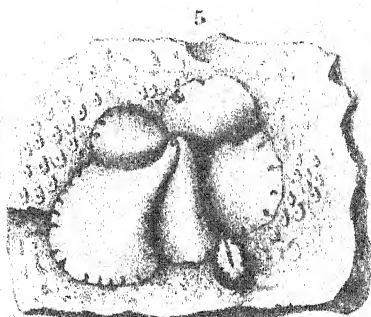
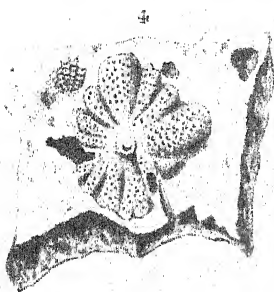
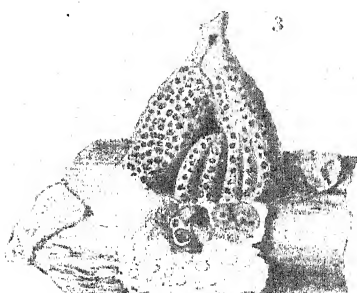
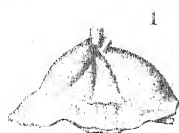


F. C. Photomicro.

Colla. by Morgan & Kidd, Richmond, S.W.

HETEROSTEGINA AND CYCLOCLYPEUS  
FROM FUNAFUTI.





F. Chapman ad nat. del.  
M. F. Parner lith.

Geo. West & Sons imp.

CARPENTERIA AND POLYTREMA FROM PUNAFUT.





- Fig. 3. *Polytrema miniaceum* (Pallas), var. *involuta*, nov. A section through part of a laminated mass, similar to that sometimes found intergrown with *Lithothamnion*. From trial pit, seaward face, Funafuti.  $\times 36$ .
4. *Carpenteria utricularis*, Carter. A vertical section of the test, showing the papillate exterior and chambers partly filled with sponge-spicules.  $\times 36$ .
5. *Carpenteria monticularis*, Carter. A vertical section taken through the base of the test, showing the smooth external surface and coarse and fine tubuli.  $\times 36$ .
6. *Cycloclypeus Carpenteri*, Brady. A full-grown specimen of the megalospheric form (A).  $\times 6$ .
7. *C. Carpenteri*, Brady. A vertical section of the test, showing the extraordinary thickness of the secondary layer of shell. The thin flange-like periphery has broken away.  $\times 10$ .

## PLATE 3.

- Fig. 1. Two series of *Cycloclypeus Carpenteri*, Brady, showing the various stages of growth in forms A (megalospheric) and B (microspheric) respectively.  $\frac{1}{2}$  nat. size.
2. The central portion of a microspheric form of *C. Carpenteri*, Brady, cut a little out of the median plane, showing an interesting resemblance in its commencement to *Heterostegina*, to which genus it bears some relationship.  $\times 36$ .
3. A half-grown specimen of the microspheric form of *Cycloclypeus Carpenteri*.  $\times 5$ .
4. A megalospheric form of *C. Carpenteri* in median section. The shell has been badly broken at various stages of growth and repaired again.  $\times 16$ .
5. The sarcode of *C. Carpenteri* (form A).  $\times 10$ .
6. A microspheric form of *Heterostegina depressa*, d'Orbigny.  $\times 10$ .
7. A megalospheric form of *H. depressa*.  $\times 10$ .

## PLATE 4.

*All magnified 5 diameters.*

- Fig. 1. *Carpenteria balaniformis*, Gray. Lateral aspect. Off Funafuti, 115-200 fathoms.
2. *C. balaniformis*, Gray. Oral aspect. Off Funafuti, 115-200 fathoms.
3. *C. utricularis*, Carter. Coloured by an alga. Lateral aspect. 8 fathoms. Off Funamanu (Beacon Id.).
4. *C. utricularis*, Carter. Coloured by an alga. Oral aspect. Off Funamanu. 80 fathoms.
5. *C. monticularis*, Carter. Oral aspect. Off Funamanu. 80 fathoms.
6. *C. monticularis*, Carter. Oral aspect. Off Funamanu. 80 fathoms.
7. *Polytrema miniaceum* (Pallas). Off Funamanu. 150 fathoms.

On some Foraminifera of Tithonian Age from the Stramberg Limestone of Nesselsdorf. By FREDERICK CHAPMAN, A.L.S., F.R.M.S.

[Read 1st March, 1900.]

(PLATE 5.)

DURING the past year or so I have been favoured by Dr. M. Remeš, of Olmütz, with some specimens of Foraminifera and a sample of foraminiferal material from the marl formed by the weathering of the Red Limestone of Nesselsdorf.

Dr. Perner has already published a paper on Tithonian Foraminifera from the Stramberg Limestone\*, in which he describes three species from the red marly limestone, namely, *Bulimina variabilis*, d'Orbigny, *Cristellaria varians*, Bornemann, and *C. rotulata* (Lam.). Beyond this record we have no information of the Foraminifera from beds of this particular age. Consequently the following small series is of exceptional interest.

## FORAMINIFERA.

### Family LITUOLIDÆ.

#### Subfamily LITUOLINÆ.

#### HAPLOPHRAGMIUM, Reuss [1860].

HAPLOPHRAGMIUM AGGLUTINANS (*d'Orbigny*). (Pl. 5. fig. 1.)

*Spirolina agglutinans*, d'Orbigny, 1846, Foram. Foss. Vienne, p. 137, pl. vii. figs. 10-12.

The specimen before us is somewhat irregular in growth, but the chief characters of the test resemble those of the above species.

Dating from the Lower Carboniferous rocks, this species ranges upwards in fossiliferous strata to the present day. It has also occurred in the mixed faunas from the Aptian beds of Surrey (*Chapman*).

One specimen from the Red Limestone of Nesselsdorf.

\* Bull. Internat. Acad. Sc. Bohême, 1898, pp. (1-3), pl. i.

HAPLOPHRAGMIUM NEOCOMIANUM, *Chapman*. (Pl. 5. fig. 2.)

*Haplophragmium neocomianum*, Chapman, 1894, Quart. Journ. Geol. Soc. vol. 1. p. 695, pl. xxxiv. figs. 2a, b.

This species was originally described from the Aptian beds of Surrey, where it was fairly numerous. The present specimen very closely resembles the original figure.

One specimen from the Red Limestone of Nesselsdorf.

### Subfamily TROCHAMMININÆ.

#### AMMODISCUS, *Reuss* [1861].

AMMODISCUS INCERTUS (*d'Orbigny*). (Pl. 5. figs. 3 & 4.)

*Operculina incertus*, d'Orbigny, 1839, Foran. Cuba, p. 71, pl. vi. figs. 16 & 17.

*Ammodiscus incertus* (d'Orb.), Wisniewski, 1890, Pamietnik Akad. Umiej. Krakow, vol. xvii. p. 190, pl. viii. (i.) figs. 11a, b.

This well-known and variable species is numerous in the present series. The two specimens here figured apparently belong to the megalospheric and microspheric forms respectively.

Common in the Red Limestone of Nesselsdorf.

### Subfamily ENDOTHYRINÆ.

#### INVOLUTINA, *Terquem* [1862].

INVOLUTINA REMESIANA, sp. nov. (Pl. 5. figs. 5 a-c.)

Test conical, depressed, consisting of a simple coiled tube of about five whorls, the sutures distinct. The inferior surface slightly convex and covered with papillæ of exogenous shell-growth, excepting the last whorl, which is marked on the periphery with sharp furrows at right angles to the edge. The test is finely perforate on the inner parts of the tubes and calcareo-arenaceous on the outer. The aperture opens on the inferior side of the test. Diameter  $\frac{1}{27}$  inch (.93 mm.); height  $\frac{1}{120}$  inch (.208 mm.).

The species *Involutina Jonesi*, Terquem & Piette\*, is in some respects similar to this form, for example in the character of the granulations, but the outline of the test is very dissimilar.

I have named this species in honour of Dr. Remeš, of Olmütz, to whom we are indebted for this interesting series of specimens.

Common in the Red Limestone of Nesselsdorf.

\* Mém. Acad. Imp. Metz, vol. xlii. 1862, p. 461, pl. vi. figs. 22a-c.

INVOLUTINA CONICA, *Schlumberger*. (Pl. 5. figs. 6 *a*, *b*.)

*Involutina conica*, Schlumberger, 1898, Feuille Jeunes Naturalistes, ser. 3, Ann. 28, No. 332, pp. (1, 2), figs. 1-3.

This species has been lately described from the Great Oolite between Villers-sur-Mer and Caen by M. Schlumberger.

The specimens now before us are, if anything, larger than those from France.

Frequent in the Red Limestone of Nesselsdorf.

### Family TEXTULARIIDÆ.

#### Subfamily TEXTULARIINÆ.

##### VALVULINA, *d'Orbigny* [1826].

VALVULINA CUNEIFORMIS, sp. nov. (Pl. 5. figs. 7 *a*, *b*.)

Test conical, flattened on opposite sides; septal face convex, with a valve-like aperture. Chambers numerous, narrow, and alternate in three series. Length of test  $\frac{1}{86}$  inch (.378 mm.). Measurement across the long and short axes of oral face of test  $\frac{1}{54}$  inch (.463 mm.) and  $\frac{1}{70}$  inch (.357 mm.) respectively.

This species is somewhat like *Textularia conica*, *d'Orbigny*\*, in its general shape. It differs, however, in the numerical arrangement of the chambers; the aperture also is characteristic of *Valvulina*.

Another form which *V. cuneiformis* resembles is *Valvulina palæotrochus*, var. *compressa*, Brady†, from the Carboniferous formation, but the latter is strongly concave on the apertural face.

Frequent from the Red Limestone of Nesselsdorf.

### Family LAGENIDÆ.

#### Subfamily NODOSARIINÆ.

##### LINGULINA, *d'Orbigny* [1826].

LINGULINA NODOSARIA, *Reuss*. (Pl. 5. figs. 8 *a*, *b*.)

*Lingulina nodosaria*, Reuss, 1862, Sitzungsab. Ak. Wiss. Wien, vol. xlv. p. 59, pl. v. figs. 12 *a*, *b*.

The specimen here figured consists of two chambers only, and

\* Foram. Cuba, 1839, p. 143, pl. i. figs. 19 & 20.

† Carboniferous Foram. (Pal. Soc.), vol. xxx. 1876, p. 85, pl. iv. figs. 5 *a*, *b*.

is probably an immature example. This species has been found in the Aptian and Albian of Germany, France, and England.

One specimen from the Red Limestone of Nesselsdorf.

*LINGULINA OVALIS*, Schwager. (Pl. 5. figs. 9 a, b.)

*Lingulina ovalis*, Schwager, 1865, Jahresh. Ver. vaterl. Nat. Württ. vol. xxi. p. 116, pl. iv. figs. 21-24.

This is here represented by a fragmentary example. It consists of three chambers, flattened and ovate, and more nearly resembles Schwager's figures than others described from similar deposits. Schwager obtained his specimens from the Lower Oxfordian of Gruibingen and Weissenberg.

One specimen from the Red Limestone of Nesselsdorf.

#### VAGINULINA, d'Orbigny [1826].

*VAGINULINA TRUNCATA*, Reuss. (Pl. 5. fig. 10.)

*Vaginulina truncata*, Reuss, 1862, Sitzungs. Ak. Wiss. Wien, vol. xlvi. p. 47, pl. iii. fig. 9.

This species now has a geological range from the Tithonian to the Cenomanian.

One specimen from the Red Limestone of Nesselsdorf.

#### CRISTELLARIA, Lamarck [1816].

*CRISTELLARIA BRONNI* (Römer). (Pl. 5. fig. 11.)

*Planularia Bronni*, Römer, 1841, Verstein. nordd. Kreidegeb. p. 97, pl. xv. fig. 14.

This is a well-known Cretaceous species.

One specimen from the Red Limestone of Nesselsdorf.

*CRISTELLARIA CALVA*, Wisniowski. (Pl. 5. fig. 12.)

*Cristellaria calva*, Wisniowski, 1890, Pamietnik Akad. Umiejet Krakow, vol. xvii. p. 223, pl. x. (iii.) figs. 4 a, b.

The above species was originally described from the *Ornatu*-zone of the Upper Jurassic of Poland.

One specimen from the Red Limestone of Nesselsdorf.

*CRISTELLARIA GIBBA*, d'Orbigny. (Pl. 5. fig. 13.)

*Cristellaria gibba*, d'Orbigny, 1839, Foram. Cuba, p. 63, pl. vii. figs. 20, 21.

Several more or less distorted varieties of this species occur in the series before us. The typical, elongated form is also present, one of which is figured.

Common in the Red Limestone of Nesselsdorf.

CRISTELLARIA ROTULATA (*Lamarck*). (Pl. 5. fig. 14.)

*Lenticulites rotulata*, Lamarck, 1804, Annales du Muséum, vol. v. p. 188. no. 3; Tabl. Encycl. et Méthod. pl. ccclxvi. fig. 5.

This widely distributed and very common form has already been recorded from the Stramberg limestone by Dr. Perner.

Common in the Red Limestone of Nesselsdorf.

CRISTELLARIA CULTRATA (*Montfort*). (Pl. 5. fig. 15.)

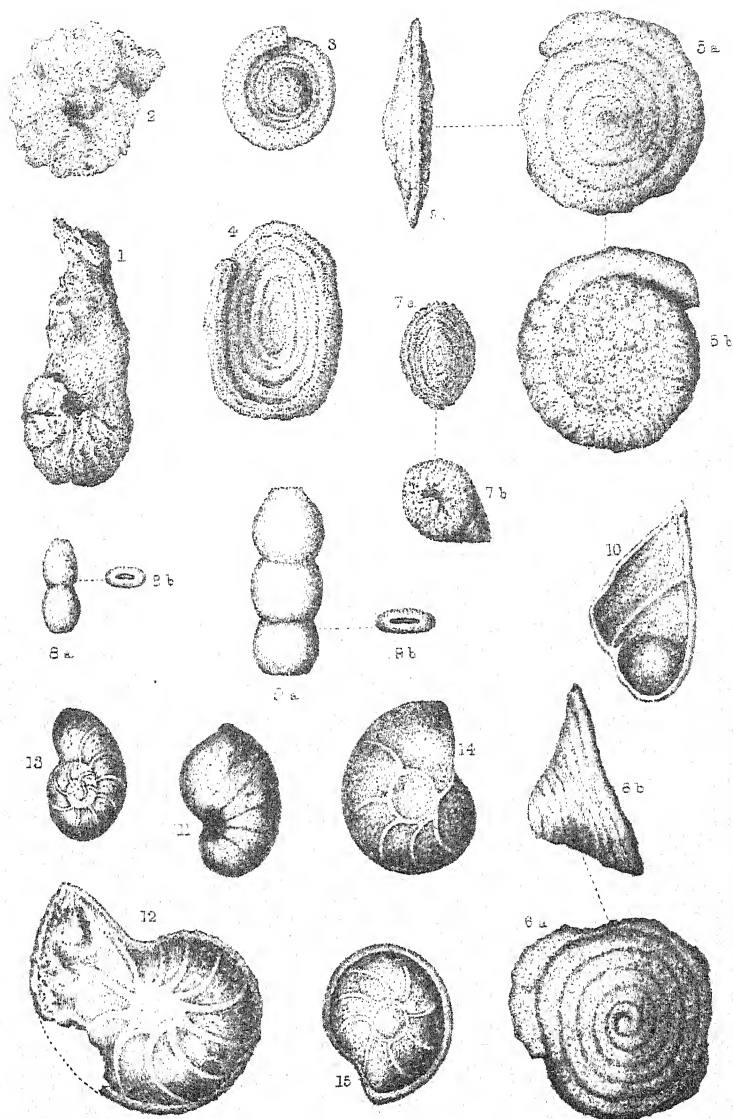
*Robulus cultratus*, Montfort, 1808, Conchyl. Systém. vol i. p. 214, 54<sup>e</sup> genre.

This species ranges from the Lias upwards.

Frequent in the Red Limestone of Nesselsdorf.

#### EXPLANATION OF PLATE 5.

- Fig. 1. *Haplophragmium agglutinans* (d'Orb.).  $\times 30$ .  
 2. „ *neocomianum*, Chapman.  $\times 30$ .  
 3. *Ammodiscus incertus* (d'Orb.). Form A.  $\times 30$ .  
 4. „ „ „ Form B.  $\times 30$ .  
 5. *Involutina Remesiana*, sp. nov.: a, superior aspect; b, inferior aspect; c, peripheral aspect.  $\times 30$ .  
 6. *Involutina conica*, Schlumberger: a, superior aspect; b, lateral aspect.  $\times 30$ .  
 7. *Valvulina cuneiformis*, sp. nov.: a, superior aspect; b, oral aspect.  $\times 30$ .  
 8. *Lingulina nodosaria*, Reuss: a, lateral aspect; b, oral aspect.  $\times 30$ .  
 9. „ *ovalis*, Schwager: a, lateral aspect; b, oral aspect.  $\times 30$ .  
 10. *Faginulina truncata*, Reuss.  $\times 30$ .  
 11. *Cristellaria Bronni* (Römer).  $\times 30$ .  
 12. „ *calva*, Wisniowski.  $\times 15$ .  
 13. „ *gibba*, d'Orb.  $\times 30$ .  
 14. „ *rotulata* (Lam.).  $\times 30$ .  
 15. „ *cultrata* (Mont.).  $\times 30$ .
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F.C. ad. nat. del.  
A.R. Hammond lith.

West. Newman imp.

FORAMINIFERA FROM NESSELDORF (TITHONIAN).





**RHYNCHODEMUS HOWESI:** a new European Species of Terrestrial Planarian Worm. By R. F. SCHARFF, Ph.D., B.Sc., Keeper Nat. Hist. Coll., National Museum, Dublin.\*

[Read 15th February, 1900.]

(PLATE 6.)

I FOUND this worm during the autumn of 1899 in the Pyrenees, close to the village of Eaux Chaudes. This village, famed for its medicinal waters, lies at a height of about 2000 feet above sea-level, in a most picturesque valley surrounded by dense forests. The worm was discovered under a stone coiled round the shell of a *Helix nemoralis*. The snail had apparently been overcome by the worm previous to being devoured, as it had retired far up into its shell and exhibited little sign of life. When I released the snail, the worm slowly crawled away, leaving an abundant track of mucus like that of a slug. I had hoped to be able to find out something more about it after a closer examination, but owing to the very dark pigment in the skin, no eyes were visible, nor were any openings to be seen on the underside. However, I had no doubt of the true nature of the worm, the general shape of the body indicating a terrestrial planarian. I believed that I had before me a gigantic member of the genus *Rhynchodemus*, and this surmise has now proved to be correct.

The width of the worm was 5 millim., and the length no less than 130 millim. (about 5 inches)—just twice as long as the largest *Rhynchodemus* hitherto known to science. The colour of the upper side was of a uniform greyish black (Pl. 6. fig. 1). The under side (Pl. 6. fig. 2) is made up of the median sole, aptly called "Kriechleiste" by Prof. von Graff, since it is a somewhat raised plate on which the animal creeps. It occupies one third of the ventral side of the body (Pl. 6. fig. 2, s) and is coloured light grey; while on each side we find a dark grey stripe bordered by a brownish-grey marginal one. The latter, which will be referred to again later on, is von Graff's "Drüsenkante" or glandular ridge. The dorsal and ventral surfaces are sharply distinct in contour, the former being convexly rounded, the latter almost flat. The anterior end of the body is not directly concerned with the creeping movements, and the sole does not extend

\* Communicated by Prof. G. B. Howes, Sec. L.S.

into it. It is finely pointed and somewhat cylindrical, and is the seat of the principal sensory organs of the body. As the animal moves about, it is kept off the ground and acts as a tactile organ much like the tentacles of a snail. In some of the Planarian worms, such as *Placocephalus kewensis* (*Bipalium kewense*), which has been taken in a few English and Irish greenhouses, this portion of the body assumes a characteristic cheese-cutter shape. The posterior end of the body of our worm is but slightly attenuated, and the sole is continued to the extreme tip.

These were all the observations that I could make during the life of the single specimen in my possession \*. I decided therefore to kill it without further delay, and placed it in a 4-per-cent. solution of commercial formalin. The immediate effect was a very considerable shrinkage of the specimen, which became reduced to a length of 75 millim. and a width of  $4\frac{1}{2}$  millim.† One advantage this treatment had on the worm was to reveal two openings on the underside. From the first, situated 40 millim. from the anterior end, a triangular body, viz., the pharynx (Pl. 6. fig. 2, *ph.*), had been partially forced out by the contraction. This larger opening is therefore the mouth, and the much more minute one (*g*), 13 millim. behind it, the genital pore.

Being unable to perceive any trace of eyes or even of a sensory groove at the anterior end of the body, I felt it would have been impossible to determine the specimen with any degree of certainty without cutting sections. In this dilemma my friend Prof. Howes offered me help. He kindly commissioned one of his students, Mr. H. H. Swinnerton, to cut me a number of microscopic sections, and to their generous assistance I owe the pleasure of being able to describe this interesting specimen, and add another species to the known European Land-planarians. The name *Rhynchodemus Howesi* is therefore appropriate.

The recent publication of Prof. von Graff's magnificent monograph on the Land-planarians (2), has rendered the identification of my specimen a comparatively easy task. To give a complete account of its anatomy would be quite impossible, as the single

\* It has now been deposited in the Dublin Museum.

† Unfortunately, the vessel containing my specimen broke on the journey from the Pyrenees to Bordeaux, but the officials of the Museum in the latter town most liberally offered me a new jar with alcohol. Owing to these adverse circumstances the preservation of the worm is not altogether satisfactory.

specimen could not be entirely sacrificed to the microtome. I content myself therefore with giving a short sketch of some of the more important anatomical features which could be gathered from a careful examination of the sections. The head and a portion of the body containing the pharynx were cut into transverse sections, whilst a small part bearing the genital pore was utilized for longitudinal ones. From these the following observations were noted :—

One of the most striking objects in the series of sections near the anterior end of the body is the pair of eyes. If we examine such a section more closely (Pl. 6. fig. 3), we notice externally the *epidermis* (*ep.*). Some previous writers, especially Prof. S. Moseley (4) and Dendy (1), have referred to the great difficulty in obtaining a clear idea of the structure of this layer from ordinary cross sections. My single specimen, as already stated, had not been fixed in a satisfactory manner for histological purposes. But whatever method is employed for fixing, the chief difficulty in recognizing the structure of the epithelium lies in the fact that the greater part of it is filled with rod-like bodies, while numerous glands open between the cells to carry their secretions to the exterior. The epithelium consists of a single layer of cells which, in this part of the body, are about equally high on the dorsal and ventral surface. The sole (*s*)—von Graff's "Kriechleiste"—possesses a ciliated epithelium, but cilia appear to be confined to this part of the under surface. The most noteworthy features in connection with this sole are the sensory grooves (*sg.*), which I failed to make out from a macroscopic examination of the worm. They are probably united in front in the form of a horseshoe, the two branches being continued backward for a little distance beyond the eyes on each side of the sole. These sensory grooves have been demonstrated in the great majority of Land-planarians by Prof. von Graff. As a rule there are also sensory pits in connection with the grooves, but according to the same author (2. p. 42) these are absent in *Rhynchodemus bilineatus*, *Rh. Scharffi*, *Rh. nematoides*, and *Rh. ochroleucus*. No trace of such pits could be seen in the cross-sections of *Rh. Howesi*, so that it agrees in this respect with some of the other species of the genus.

Almost all previous writers on the Land-planarians have referred to the peculiar rod-like "*Rhabdites*," which have been compared to the stinging-organs of Cœlenterates, but whose

precise function is still unknown. It has been suggested that they serve for the capture of the prey; and this explanation is supported by the observations of Dendy (1) and Woodworth (6). Prof. von Graff distinguishes three varieties of rod-like bodies (2. p. 55), viz.:—"Rhabditen, Rhamniten, and Chondrocysten," but observes that there is no real difference in kind—that the Rhamniten and Chondrocysten in fact only indicate the extremes in both directions of the true Rhabditen. The Rhabditen are short and stout, the Rhamniten longer and much more slender, while the Chondrocysten are oval or club-shaped masses. I could clearly trace the latter form in many of the sections and also the Rhabditen, but failed to perceive any rods that could be brought under the second denomination.

As regards the glands which lie in the connective-tissue and open on the surface of the epidermis, only one kind is noticeable in the section referred to. They convey mucus to the skin, and become deeply stained by hæmatoxylin and less so by borax-carmin, which were the reagents used. Portions of mucus in the ducts between the epithelial cells are frequently seen, and lead one to mistake them for Rhabditen, but the latter are pointed at each end, and by that means can be distinguished. In the more posterior sections very large glands are noticed near the margins of the lower body-surface. These—the "Kantendrüsen" of Graff—are confined to that part of the body, and will be referred to later on.

The *muscular* and *nervous systems* are dealt with so exhaustively by Prof. von Graff, Prof. Dendy, and others, and there appears to be so little difference in the various species, that a detailed description of the necessarily incomplete observations I have been able to make, appears undesirable. There are a deep and a superficial muscular system, while the nervous system consists of two longitudinal cords, with an anterior bilobed ganglionic mass or brain. The section (Pl. 6. fig. 3) being slightly oblique, only one half of the brain (*b*) is visible. Close to it on the dorsal portion of the head lie the *eyes*, one on each side. One of them (*e*) is represented in the section. Prof. von Graff has drawn attention to the fact that two very distinct types of eyes occur among the Land-planarians. These two types he called "Invertirte Kolbenaugen" and "Retinaaugen." In the first type, the retina is placed in front of the eye, and the sensitive cells are turned away from the source of light, hence the term

“inverted club-shaped eyes.” The eyes of *Rh. Howesi* belong to the other or “retina” type. It consists simply of a cup-shaped organ internally coated with small pigment-cells and surrounded by a retina, so that the latter is placed facing the light. The open part of the cup is covered by a non-pigmented layer of cells—a kind of cornea. The latter has a thickness of 0.012 millim.; while the whole eye is 0.16 millim. long, and at its widest part 0.108 millim. broad. The interior of the eye is partly filled with a peculiar cellular substance, whose true nature could not be ascertained from any of the sections available. I had no means of comparing the sections with longitudinal ones, and must presume that this structure is similar to that figured by Prof. von Graff (2. pl. 50. fig. 1). He explains (p. 144) that it is composed of a bundle of elongated columns, one end of which converges towards the centre of the eye, whilst the others are connected with the retina-cells by means of fine prolongations which pass outward between the pigment-cells.

*Connective-tissue* (Pl. 6. fig. 3, *c.t.*) binds together the various organs and structures lying within the epidermis and maintains them in position. It consists of a mass of fibres containing nuclei, and bearing also the generally small pigment granules which produce the black colour of the skin. The *digestive organs* do not extend to the most anterior part of the body, and are therefore not visible in the section (Pl. 6. fig. 3), but a little farther back we find a considerable part of the transverse sections occupied by the alimentary canal (text-fig. 1, *al*).

All Land-planarians and also the marine and freshwater Tricladæ agree in the possession of an alimentary canal consisting of three main branches and a muscular pharynx. One of the main branches runs anteriorly, the two others (text-fig. 1, *r.al.*, *l.al.*) occupy the posterior portion of the body, and they all join in a common opening in front of the pharyngeal sac.

I have already mentioned that the pharynx had become protruded through the mouth during the violent contractions when the worm was preserved. The mouth, as stated, is situated 40 millim. behind the anterior end of the body, and is indicated by a minute transverse slit scarcely visible in the living animal. The large pharynx, as seen in text-fig. 1 (*ph*), is somewhat cylindrical, and conically pointed at the free end. The transverse section figured is close to the external pharyngeal opening, and shows peculiar folding of the pharyngeal epithelium. Cilia were

noticed only on the conical end portion of the pharynx. All the three branches of the alimentary canal give off lateral diverticula. None of them appear to be ciliated. There are a few other points in the section referred to (*cf.* text-figs.) which deserve to

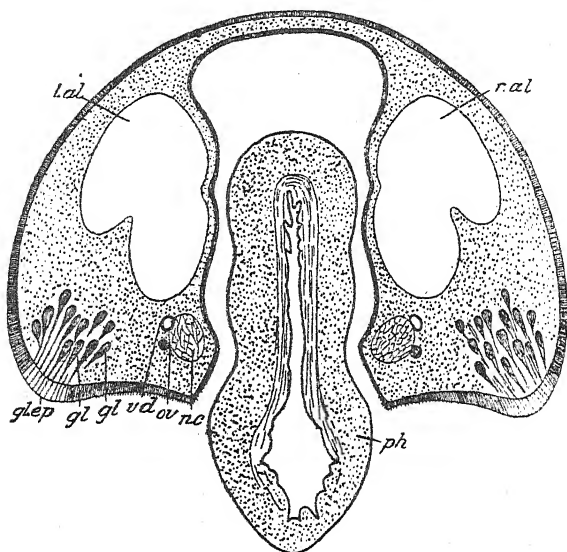


Fig. 1.—*Rhynchodemus Howesi*. Transverse section through mouth (somewhat diagrammatic).  $\times 70$ .

*glep*, glandular epithelium; *gl*, glands; *v.d.*, vas deferens; *ov*, oviduct; *n.c.*, nerve-cord; *ph*, pharynx; *r.al*, right branch of alimentary canal; *l.al*, left branch of alimentary canal.

be mentioned. I have already briefly alluded to the glands which are so very abundant in the section near the anterior end. But farther back, where the underside is divided into three distinct areas, a number of large glands are seen to open on the surface towards the sides of the body. These are roughly indicated on the transverse section (text-fig. 1, *gl*). They are what von Graff described as "Kantendrüsen," and are strictly localized to that particular portion of the body. They are deeply stained by hæmatoxylin like the other glands, and their ducts have deformed the epithelial cells between which the glands conduct their secretions to the exterior.

In one important respect these epithelial cells differ from all those described by von Graff, namely, in size. He remarks

(2. p. 43) that the height of the "Drüsenkanten-epithel" is less than that of the dorsal epithelium, while I find (*gl.ep*) that it greatly exceeds that in height. Another interesting fact worth noting is that *Rh. Howesi* is the only member of the genus *Rhynchodemus* in which these peculiar marginal glands occur. The cilia so well seen towards the middle of the underside do not extend to this glandular area.

All Land-planarians are hermaphrodite, a pair of ovaries being situated near the anterior end of the body. These give rise to an oviduct on each side of the body (*cf.* text-figs., *ov.*), which generally unite before opening posteriorly into the genital atrium. The testes lie farther back than the ovaries, and the two vasa deferentia (*v.d.*), carrying the spermatozoa, open as a rule separately into the vesicula seminalis (*v.s.*), from which a duct leads into the genital atrium. The genital opening is always situated behind the mouth. In *R. Howesi* it is only very faintly indicated by a minute white spot (Pl. 6. fig. 2, *g*) on the underside of the body, 13 millim. behind the oral aperture.

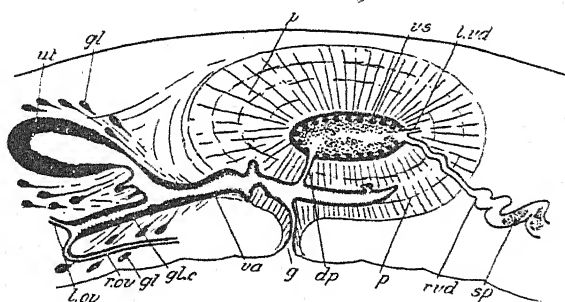


Fig. 2.—*Rhynchodemus Howesi*.—Longitudinal section through reproductive organs (somewhat diagrammatic).  $\times 50$ .

*ut*, uterus; *l.ov.*, left oviduct; *r.ov.*, right oviduct; *va*, vagina; *gl*, glands; *p*, penis; *v.s.*, vesicula seminalis; *g*, genital pore; *g.l.c.*, glandular canal; *sp*, spermatozoa; *dp*, duct from vesicula seminalis; *r.v.d.*, right vas deferens; *l.v.d.*, left vas deferens.

Instead of giving an accurate drawing of a longitudinal section of the *reproductive organs*, it seemed to me preferable to show the disposition of the various parts in *Rh. Howesi* by means of a somewhat diagrammatic sketch (text-fig. 2). The reproductive organs in this species agree in the main points with those of *R. terrestris* and *R. Scharffi*, but they are more nearly related



to those of the former. The oviducts (text-fig. 1, *ov*) lie close to the nerve-cords (*n.c.*), one on each side, in which position they run from the anterior ovaries backward beyond the genital pore and open independently into a wide glandular canal (text-fig. 2, *gl.c.*), as in *Rh. terrestris*. This canal is characterized by the possession of very elongated and ciliated epithelial cells between which open numerous glands (*gl*)—von Graff's shell-glands. During their course the oviducts receive the contents of many yolk-glands. Every now and then, in transverse sections, short cylindrical ducts conveying food-material for the eggs are noticed opening into the oviducts. The latter, it may be mentioned, are ciliated. The glandular canal (*gl.c.*) opens anteriorly into another, the vagina (*va*), and it is joined there by a duct from a large glandular organ—the uterus (*ut*).

The numerous testes are arranged in a row on each side of the body close to the upper side of the nerve-cords. Two vasa deferentia (text-fig. 2, *v.d.*) convey the spermatozoa towards the muscular mass of the penis (*p*). But before they reach it they become dilated to form thin-walled convoluted ducts, which in the specimen examined were filled with masses of agglutinated spermatozoa (*sp*). Each of the vasa deferentia opens independently into a sac—the vesicula seminalis (*v.s.*)—which is surrounded by an enormous muscular mass constituting the penis (*p*). A narrow duct (*d.p.*) leads from the vesicula seminalis to the genital atrium, into which also opens the vagina. The atrium finally communicates with the exterior (*g*) by a short duct. The vesicula seminalis (*v.s.*), under a low power of the microscope, appears to be coated internally with a thick glandular epithelium projecting far into the lumen of the organ. But a high power reveals the fact that the epithelium is thrown into short folds which are closely invested by a thick granular mass. Whether the latter is secreted by the epithelium or by glands lying on the exterior of the muscular penis, I was unable to ascertain.

In the closely allied *Rh. Scharffi* (2. fig. 53, p. 203), the penis lies freely in the surrounding tissue, and is probably eversible to a considerable extent, while in that of the present species the movements would seem to be much more limited.

This concludes my observations on the general structure of *Rh. Howesi*; and it still remains for me to make a few remarks

on its systematic position and relationship. The 348 species of Land-planarians are now divided into five great families, viz. :—

Limacopsidæ.

Geoplanidæ.

Bipaliidæ.

Cotyloplanidæ.

Rhynchodemidæ.

Of which the latter is defined by Prof. von Graff as possessing two eyes near the anterior end of body, whilst tentacles, sucking-discs, and head-plates are absent. There can be no doubt, therefore, from the description given above, that the new Pyrenean species belongs to that family. The latter includes the seven genera *Rhynchodemus*, *Microplana*, *Amblyplana*, *Nematodemus*, *Platydemus*, *Dolichoplana*, and *Othelosoma*. The genera *Microplana* and *Amblyplana* are devoid of sensory grooves; and *Nematodemus* has no sole, whilst both sensory grooves and a sole are present in the species described. The genera *Platydemus* and *Dolichoplana* have sensory pits which are absent in our species; and finally *Othelosoma* is distinguished from all other members of the family by the possession of a peculiarly folded and attenuated head-region.

In fact the new European land-planarian undoubtedly belongs to the genus *Rhynchodemus*, and its nearest relation appears to be *Rh. terrestris*. It differs, however, from the latter in being more than 12 times as long, in the possession of rhabdites, of a marginal glandular area on the underside of the body, and in many minor structural points in the reproductive organs.

As regards the geographical distribution of the family Rhynchodemidæ, it is the only cosmopolitan one, and two of its genera, viz. *Rhynchodemus* and *Microplana*, have been found in Europe. The last genus in fact, with its single species *M. humicola* (first described by Prof. Vejdvosky), is confined to our Continent. Thirty-four species of *Rhynchodemus* are known to science, of which five, viz., *Rh. terrestris*, *Rh. bilineatus*, *Rh. pyrenaicus*, *Rh. albicollis*, and *Rh. Scharffi*, occur in Europe. To these must now be added *Rh. Howesi*. Some of them are apparently very local forms, *Rh. bilineatus* and *Rh. albicollis* having only been found in Germany, *Rh. pyrenaicus* and *Rh. Howesi* in the Pyrenees, and *Rh. Scharffi* in Ireland; but *Rh. terrestris* has a much wider range. It is known from Denmark, England, Ireland, France, Germany, Austria, and the Balearic Islands,

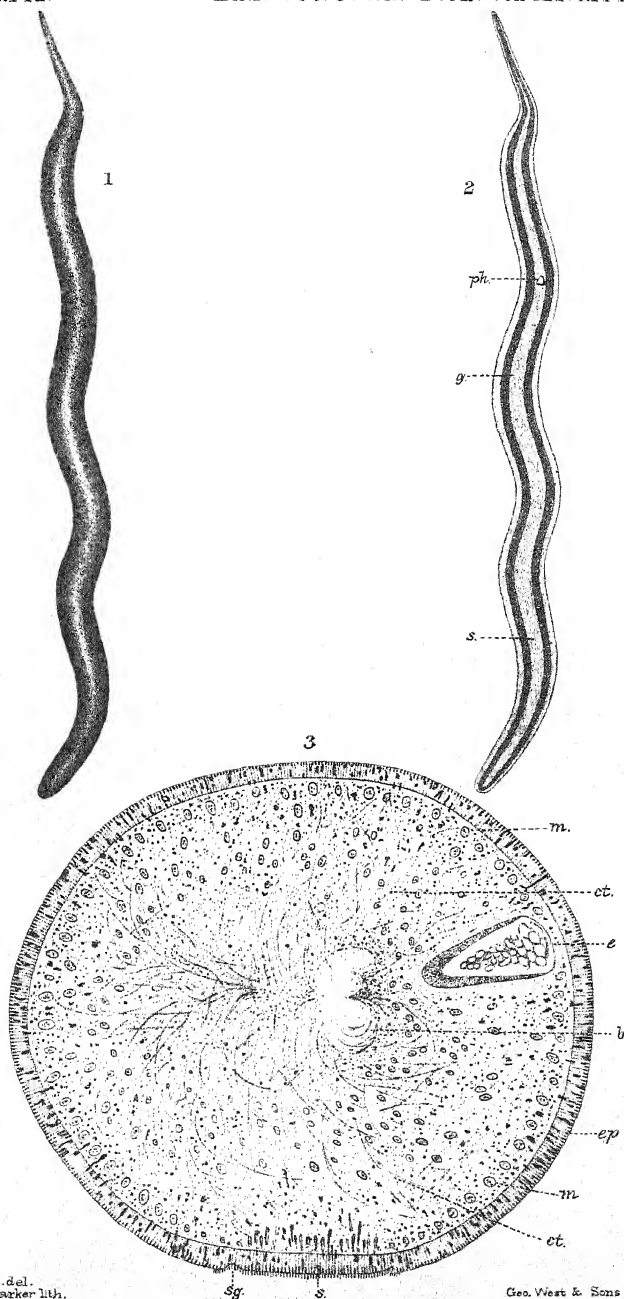
whilst I took it myself some years ago on the Brünig Pass, in Switzerland. Though some of the European species have been discovered under somewhat suspicious circumstances, which render artificial importation probable, I quite agree with Prof. von Graff in the opinion that all the European Rhynchodemidae are truly indigenous to our Continent.

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## DESCRIPTION OF PLATE 6.

- Fig. 1. *Rhynchodemus Howesi*, natural size, dorsal aspect.
2. The same, natural size, ventral aspect.  
*ph.*, pharynx; *g.*, genital aperture; *s.*, sole.
3. The same. Transverse section through anterior region,  $\times 435$ .  
*e.*, eye; *b.*, brain; *ep.*, epidermis; *m.*, longitudinal muscular bundles;  
*s.*, sole; *sg.*, sensory groove; *ct.*, connective tissue.



R.F.S. del.  
M.P. Parker lith.

Geo. West & Sons imp.

RHYNCHODEMUS HOWESI, Scharff.



Bryozoa from Franz-Josef Land, collected by the Jackson-Harmsworth Expedition, 1896-1897. By ARTHUR WILLIAM WATERS, F.L.S.

[Read 15th March, 1900.]

(PLATES 7-12.)

#### CHILOSTOMATA.

THE Arctic Bryozoa from various localities have been well studied, having received attention from several leading workers, including Smitt, Busk, Hincks, Lorenz, Vigelius, &c. That they should have been so thoroughly examined is no doubt accounted for by the fact that, when any important expedition returns, specialists are found to work up all the material collected under trying circumstances, while collections from less accessible places are put aside without description.

The question arises what should be considered Arctic, for the Arctic circle forms but an artificial zoological division, and it would be simpler to include in "Arctic" everything within the isothermal line of 32° F. (0° C.). This brings in practically the whole of Greenland, Davis Straits, Labrador, and Iceland. The Gulf of St. Lawrence is not included; but as many Bryozoa have been described from there, and seeing that many of them occur in Arctic regions, they must be compared. If we were to take the winter isotherm, the Gulf of St. Lawrence would be included in a line passing through the south of Greenland, and by the island of Jan Mayen.

A small collection of 19 species, brought by Leigh Smith from Franz-Josef Land, was described by Ridley<sup>1</sup>.

The most important works for determining the northern Bryozoa are Smitt's series<sup>2</sup> of valuable papers published in the Proceedings of the Swedish Academy; and when examining Arctic forms we appreciate the thoroughness of his labours, although now attention is paid to several characters which were not then used, and material progress has been made in classification. Besides his papers on the Scandinavian forms, he published a descriptive list<sup>3</sup> of 58 species collected by

<sup>1</sup> "Polyzoa, Cœlenterata, and Sponges of Franz-Josef Land," *Ann. Mag. Nat. Hist.* ser. 5, vol. vii. p. 442, pl. xxi.

<sup>2</sup> F. A. Smitt. "Krit. Förteck. öfver Skand. Hafs-Bryozoer," *Cefversigt af K. Vet.-Akad. Förh.* 1865-1871 (referred to as "Krit. Fört.").

<sup>3</sup> *Cefversigt K. Vet.-Ak. Förh.* 1878, p. 11.

Nordenskiöld, Stuxberg, and Théel from Novaya Zemlya and the mouth of the Jenisei; and another list<sup>1</sup> of the collection of 74 species made by Sandberg and Trybom from the Kola peninsula. Further<sup>2</sup>, Smitt's "*Bryozoa marina in regionibus arcticis et borealibus viventia recensuit*" gives a valuable *résumé* of what was then known.

The late Mr. Hincks<sup>3</sup> published a paper on "Iceland and Labrador Polyzoa;" and the same author's papers<sup>4</sup> on the Bryozoa from the Gulf of St. Lawrence give exact descriptions and figures of various Arctic species. Mr. Hincks furnished the list of species from Barents Sea in W. S. M. D'Urban's paper<sup>5</sup> "*Zoology of Barents Sea*," and described some new species in the same volume of the '*Annals*,' p. 272.

Busk<sup>6</sup> described some Bryozoa collected from Greenland, &c. by Dr. Sutherland and S. E. Belcher; and the next year had a paper in the '*Annals*'<sup>7</sup> on a collection made by Mr. McAndrew on the coasts of Norway and Finland. The same author published<sup>8</sup> in 1881 a description of Arctic Bryozoa collected by Captain Feilden.

An Austrian expedition, sent out by Count Wilczek to the island of Jan Mayen, north of Iceland, collected 75 species, which were ably described by L. Lorenz<sup>9</sup>. G. Levinsen<sup>10</sup> has written a valuable paper on 51 species of Bryozoa from the Kara Sea.

Vigeli<sup>11</sup> has a list of 27 species collected by the '*Willem Barents*.'

<sup>1</sup> Öfversigt K. Vet.-Ak. Förh. 1878, p. 19.

<sup>2</sup> *Ibid.* 1867, p. 443.

<sup>3</sup> Ann. & Mag. Nat. Hist. ser. 4, vol. xix. p. 97. Mr. Hincks afterwards found that instead of coming from Iceland the species so named were from Davis Straits.

<sup>4</sup> *Ibid.* ser. 6, vol. i. p. 214, & vol. ix. p. 149.

<sup>5</sup> *Ibid.* ser. 5, vol. vi. p. 257.

<sup>6</sup> Quart. Journ. Mier. Sc. vol. iii. 1855, p. 253.

<sup>7</sup> Ann. & Mag. Nat. Hist. ser. 2, vol. xviii. p. 32.

<sup>8</sup> Journ. Linn. Soc., Zool. vol. xv. p. 231.

<sup>9</sup> "Bryozoen von Jan Mayen." Oesterreichische Polarstation Jan Mayen. Beobachtungs-Ergebnisse, vol. iii. p. 83, 1886: Internat. Polarforschung.

<sup>10</sup> "Bryozoen fra Kara-Havet," Dijnphna-Togtets Zool.-Bot. Udbytte, 1886, p. 307.

<sup>11</sup> "Catalogue of the Polyzoa coll. during the Dutch N. Polar Cruise of the '*Willem Barents*' in the year 1878-1879," Nied. Arch. für Zool., Suppl. vol. iii.

Kirchenpauer<sup>1</sup> has described Bryozoa from East Greenland: Andeer Hennig<sup>2</sup> 27 species from West Greenland; and Nordgaard<sup>3</sup> has published a useful paper on the Bryozoa from the coasts of Norway, in which he gives a list of Arctic literature, to which I would specially call attention, as there are several papers by M. Sars, G. O. Sars, Kirchenpauer, Danielssen, and others to which the worker may have to refer, but which need not be enumerated here.

Stuxberg<sup>4</sup> has given a valuable list from the district of Novaya Zemlya; but when the older nomenclature is used we cannot always be certain what was intended, and may have two names for the same form: for instance, *Leieschara subgracilis* = *Myrionozoum subgracile*.

Recently Olaf Bidentkap<sup>5</sup> has written an important paper on the Bryozoa from East Spitzbergen.

E. von Marenzeller<sup>6</sup> named twelve Bryozoa dredged by the Austrian North Pole Expedition, and a few of these are from localities a degree or two farther east than any of the Jackson-Harmsworth dredgings, though not so far north, and most are from a depth of about 200 metres. In order to better understand the manner in which distribution has taken place, we now want collections from the neighbourhood of New Siberia and the Behring Straits.<sup>7</sup>

Smitt, who described so many Arctic forms, undoubtedly often united under one name quite distinct species, and much time is lost in considering which are correct specific names. The difficulty is increased by so many species being based, by many authors, originally upon the form of growth, without any

<sup>1</sup> "System. Verzeich. der in Ostgrönland gesammelten Hydroiden u. Bryozoen" in Koldewey, 'Die zweite deutsche Nordpolfahrt,' Bd. II. Abth. 1, 1874, p. 411.

<sup>2</sup> "Bryozoeer från Westgrönland samlade af Dr. Ohlin 'under the Peary Auxiliary Expedition,' år 1894." Öfvers. K. Vetensk.-Akad. Förh. 1896.

<sup>3</sup> "Syst. fortæg. ov. de i Norge, hidtil observ. arter af Marine Polyzoa." Bergens Museums Aarbog 1894-5, No. 2.

<sup>4</sup> "Faunan på och kring Novaja Semlja, Vega-Expeditionens," Vetenskaplige Arbeiten, vol. v. 1887, pp. 100, 117, & 179.

<sup>5</sup> "Bryozoen von Ost-Spitzbergen," Zool. Jahrb. vol. x. 1897, p. 609, pl. 25.

<sup>6</sup> "Die Coelent., Echin. u. Würmer der k.-k. Oest.-Ung. Nordp.-Exp.," Denksch. Akad. Wissensch. Wien, xxxv. p. 388.

<sup>7</sup> Since my paper was read an important contribution has been published by O. Nordgaard on "Polyzoa," collected in the North Atlantic, in the Reports of the Norske Nordhavs-Expedition, 1867-1878, pt. xxvii.



adequate descriptions of the zoëcia or of the minute characters. The name is accepted, and subsequently more detailed description has been given, though there is the possibility of this only relating to a similar form. We have an example in *Cellepora incrassata* of Lamarck, the name being first given to a Mediterranean species; but under this name Smitt described more thoroughly a northern form, which has been thus generally known, while a Mediterranean one has been described under another name. In such a case it seems better to consider this as the species of Smitt, who more fully described it; and to replace the present recognized name by another would only add confusion, and this is often the result of too pedantically endeavouring to follow rules.

In many cases, purposely, only one or two references are given, even where the name has been employed by various authors; but, as far as possible, only descriptions about which there was a reasonable certainty have been referred to, leaving out probabilities.

Since Smitt published his papers, the details of the structure of the zoëcia have been more carefully examined, and it has been necessary to give attention to many points which are now recognized as furnishing specific characters, for it is known that the general appearance is subject to great variation. The use of the opercula and mandibles in determining species, which I introduced in 1878\*, has been most valuable, and these characters are receiving increasing attention. The ovicells are more carefully examined than they were at the time Smitt began his work. The position and form of the rosette-plates should always be examined when circumstances permit; as also whether the connection is direct from zoëcium to zoëcium, or through a pore-chamber†.

The position of the rooting process is another character of considerable value. In the Cyclostomata the position and nature of the "closures" are characters which should not be overlooked. The glands at the side of the oral aperture and in the avicularian chamber differ considerably in position and size according to the species, and there are many species which I should recognize from sections of the soft parts; and no doubt, as

\* "The Use of the Opercula in the Determination of the Cheilostomous Bryozoa," Proc. Manch. Lit. & Phil. Soc. 1878, vol. xviii. p. 8, pl. i.

† See Waters, "Observations on Membraniporida," Linn. Soc. Journ., Zool. vol. xxvi. p. 654.

time advances, such sections will be more largely employed, and then internal organs may prove as useful in classification as the outside shell.

The number of tentacles \*, although subject to a small range, should always be given ; while a more general acquaintance with the primary cell may cause a modification of views.

The collection under review, which is one of considerable importance, was sent to me in 1898, but until other work was finished it was impossible to devote myself seriously to the task. Since then sections have been cut in all cases where the material was at all suitable, slides of the opercula and mandibles of most species have been prepared, and calcareous sections of a few have been made. The collection was sent to me by Mr. Bruce, the naturalist on the Expedition, by whom a large part of the material was collected in 1897 ; and I take this opportunity of thanking Mr. Bruce for his kindness in entrusting me with the examination of the Bryozoa.

It will be well to separate the Bryozoa into four divisions, namely :—

No. 1. Those from the neighbourhood of Northbrook Island, where the Expedition wintered. The localities are Günther Sound, Cape Flora, off Elmwood, off glacier between Cape Flora and Cape Gertrude.

No. 2. Near Wilczek Land, 127 fathoms.

No. 3. Lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 25' E.$ , 115 fathoms ; lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 20' E.$ , and  $53^{\circ} 16' E.$ , 130 fathoms. These, and also those collected from No. 2, were dredged by the 'Windward' on its third journey to Franz-Josef Land. These last are interesting as extending our knowledge of the Bryozoa farther to the east ; for, with the exception of a few specimens described by Marenzeller, no Bryozoa have been mentioned from any locality so far eastward. A further interest attaches to this part of the collection, as Mr. Bruce informs me that they were collected by Captain Brown and Mr. Edward Else, the steward, to whom Mr. Bruce had, on a previous occasion, shown the method of collecting with a "swab" and had instructed them in the preservation of the material. This shows how much useful

\* The tentacles can be readily counted in transverse sections, and figures obtained from sections are more reliable than those from living specimens.

collecting may be done in out of the way regions by men who are not trained zoologists.

No. 4. Off Cape Mary Harmsworth, 53-93 fathoms, and 234 fathoms. This is the most northerly locality whence Bryozoa have been described.

In this paper special consideration has been given to the question of geographical distribution; and we find that most of the species are widely, in fact generally, distributed in the Arctic regions, forming a very distinct Arctic fauna, with a large proportion only found in the northern seas.

Out of the 59 species of Chilostomata, *Hippothoa hyalina* is cosmopolitan, being found in the Southern hemisphere. *Porella concinna* may have been found in the Southern hemisphere, but of this I have some doubt. Then we have the *Escharoides Sarsii*, Sm., and *Cribrilina punctata*, Hass., said to have been dredged in the Antarctic by the 'Erebus' and 'Terror'; and to these I have alluded at some length, and expressed my opinion as to the probability of a mistake in labelling having been made.

There are only 20 species common to the British coasts, including some from the Shetland Islands; and the strikingly small number of 5 also known from the Mediterranean.

When the Cyclostomata and Ctenostomata have been described, the total number will be over 70; but this must not be looked upon as a complete list of Bryozoa from Franz-Josef Land, and I am convinced that many more encrusting species will be found upon dead shells.

In this paper reference is made to work previously done in the Arctic seas, and some species not found by this Expedition are given.

A point which is now attracting attention is, what species occur in the colder regions of the two hemispheres, and before long the expeditions being sent to the Antarctic will help to settle some uncertain points. Sir John Murray, in his \* "Marine Fauna of the Kerguelen Region of the Great Southern Ocean," gives a list of 16 species of Bryozoa from the Northern and Southern Hemispheres, unrecorded within the tropics; but on a critical examination this list, compiled from Busk's 'Challenger' Report, is much reduced.

\* Trans. Roy. Soc. Edin. vol. xxxviii. p. 454.

CRIBRILINA MONOCEROS, Busk, is given from Station 253, from a depth of 3125 fathoms; but my attention has been called to the fact that at this depth the calcareous shell would have been dissolved, and probably a mistake has been made in labelling.

BEANIA MAGELLANICA, Busk, has a very wide distribution, and has not yet been found near the Arctic regions; but, on the other hand, occurs in the Tropics, off Cape Verd, thus removing it from the list.

ESCHAROIDES VERRUCULATA, Busk, collected by the 'Challenger' from Heard Island, I have again examined, and find it is the *Rhynchopora longirostris*, Hincks, and not the same as the *Cellepora verruculata*, Smitt, from Florida.

In my paper on Membraniporidae\* I showed that MEMBRANIPORA CRASSIMARGINATA, var. INCRUSTANS, Busk, so far as concerned one specimen, was *M. lineata*, L.; another specimen was what I have named *M. incrustans*; while one poor specimen probably is *M. crassimarginata*, H.; and if this is the case, then the distribution thereof is Naples, Capri, Villefranche-sur-Mer, Madeira, Tizard (China Sea) (*Kirkpatrick*), Tristan da Cunha (*Chall.*), and a variety from Japan, so that it is confined to temperate seas.

*Membranipora perfragilis*, H., to which some of the 'Challenger' specimens named *crassimarginata* really belong, has a distribution from South to North Australia, on to Japan, and also Heard Island (Indian Ocean), thus occurring in both hemispheres and the tropics.

With regard to MEMBRANIPORA GALATEA, var. *multifida*, Busk, from off the Azores, I came to the conclusion, on an examination some time ago, that this was not correctly placed, but did not make a note of this at the last re-examination of 'Challenger' specimens. I have not critically examined the KINETOSKIAS CYATHUS, W. Thoms., but the two localities of the 'Challenger' are in temperate seas, not far from the tropics.

The less we say about the Cyclostomata the better, as there is much uncertainty about their determination, and without good specimens with well-preserved ovicells we may go astray, and many of the 'Challenger' determinations had to be made from single and not very satisfactory specimens. The "HORNERA LICHENOIDES," Pont., from the South Atlantic, off the River Plate, has very pronounced ridges with ribs across, and it

\* Journ. Linn. Soc., Zool. vol. xxvi. p. 686.

would be advisable to examine and make sections of some well-preserved specimens.

The "IDMONEA ATLANTICA," Forbes, from off Simon's Bay, S. Africa, does not seem to me to be this species, and the small piece from Kerguelen is also open to doubt.

With regard to ENTALOPHORA, there is so much uncertainty about their determination, that attaching a name sometimes merely means that no characters are found by which separation can be made; also no doubt these simpler forms are older, and have a wider distribution than some of the more highly differentiated.

In the present paper the genus *Scrupocellaria* is enlarged to include one or two species previously placed under *Menipea*, a genus which has incorporated some rather divergent forms.

The *Schizoporella hyalina*, L., is considered to belong to *Hippothoa*, on account of the reproductive characters.

The genus *Porella* is well represented in the Arctic Seas; and in this genus the opercula and mandibles are found of great use in separating the species, and the large avicularian and oral glands may be found similarly useful.

The *Eschara elegantula* of d'Orbigny is found, upon a comparison of d'Orbigny's specimen, not to be identical with Smitt's *Eschara elegantula*, which is in consequence left as *Porella saccata*, Busk.

The Arctic genus *Rhamphostomella*, Lorenz, has a more or less triangular or oval avicularium in the peristomial elevation, and usually has a denticle in the oral aperture. It seems more nearly related to *Smittia* than to *Cellepora*.

The *Celleporæ* all belong to the group separated off as *Osthimosia* by Jullien, and *Schismopora* by MacGillivray. Of the *Reteporæ*, one is purely Arctic and the other is thought to be the same as a Mediterranean species.

#### 1. GEMELLARIA LORICATA (L.). (Pl. 7. fig. 4.)

A specimen from Günther Sound, 10 fath., shows that there are creeping stolons, which at short intervals have adnate zoecia somewhat resembling those of *Pyripora catenularia*, Jameson. The erect branches may for a time be simple tubes, or they may at once take the usual biserial form. I cannot agree with Mr. Hincks when he speaks of the shoots rising from bundles of fibres, as this is rather reversing the case, for from individual mature zoecia radicle fibres are produced which unite

into a bundle. I find 13 tentacles, while Van Beneden and Farre speak of 10, Sars 12, Dalyell 12-14, and Vigelius 12.

*Loc.* This is a northern form, ubiquitous in the Arctic, and occurring off the British Isles and the coast of France.

Jackson-Harmsworth Exp.: Günther Sound, 10 fath.; off Cape Gertrude, 30 fath.; nr. Wilczek Land, 127 fath.; lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 20' E.$ , 130 fath.; off Cape Mary Harmsworth, 53-93 fath., and 50 miles N.W. Cape Mary Harmsworth, 234 fath.; off glacier between Cape Flora and Cape Gertrude, 30 fath.; Cape Flora off West Bay, 8 fath.

2. *BRETTIA FRIGIDA*, sp. nov. (Pl. 7. figs. 1-3.)

There are two species of *Brettia* collected by the Expedition, and this one may be what Smitt figured, pl. xviii. fig. 27, and which is referred to on page 292, Öfvers. Vetensk.-Ak. Förhandl. 1867, under *Bugula quadridentata*. In the explanation of the plates it is called an *Eucratea*-growth of *B. quadridentata* from Spitzbergen, 20 fathoms, but the growth is different from that of *Bugula*.

The zoarium grows to about three-quarters of an inch high.

The zoecia are unilateral, growing from the dorsal surface, with one distal or central rosette-plate and two lateral (fig. 3). The fresh branches arise at intervals of one, two, or three zoecia; and the two new zoecia do not spread out much, but at first are usually nearly parallel, the one growing from slightly lower down than the other. The area is surrounded by a raised border, and occupies more than half of the length of the zoecium. Sometimes a very minute spine can be seen at the oral end on one side, but more frequently no trace is visible. The radicle tubes grow from the distal end. There are 22 tentacles.

The area is quite similar to that of *Bugula*, but in most *Bugula* there is a row of distal rosette-plates, though *B. Murrayana*, Johnst., has connections like those of *Brettia frigida*. This latter resembles *Maplestonia simplex*, MacG., in some particulars, but there are no annulated joints. In *Brettia*, as first defined, there are marginal spines; but Busk, in the 'Challenger' Report, describes from Station 196 (North of Australia) *B. australis*, B., without any spines. The *B. cornigera*, Busk, is similar in shape to the present form, but has 4 submarginal spines. Busk undoubtedly is incorrect when he says "springing from a common stem of radicle tubes," for in the Bryozoa the radicle tubes always grow from the mature zoecia. Ovicells are unknown

in *Brettia*. Hincks made a genus *Corynoporella* for a species somewhat similar to the present, but with an articulated avicularium at the side of the aperture. Probably the genus is superfluous.

*Loc.* Off Cape Mary Harmsworth, 53-93 fathoms; Cape Flora off West Bay, 8 fath.; lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 20' E.$ , 130 fath.

### 3. *BRETTIA MINIMA*, sp. nov. (Pl. 7. figs. 5-7.)

The zoëcia are longer and more delicate than in *B. frigida*, W., and the area occupies about one-third of the length of the zoëcium. The branching takes places frequently, with an interval of one or two zoëcia, and spread out at a considerable angle, nearly at a right angle, much in the same way as in *Alysidium Lafontii*, Aud., so that *B. minima* can be distinguished from *B. frigida* without a lens.

The radicles start from the dorsal surface at the distal end.

*Loc.* Jackson-Harmsworth Exp.: Cape Mary Harmsworth, 53-93 fathoms.

### 4. *BUGULA MURRAYANA*, *Johnst.*

From Franz-Josef Land there are specimens of characteristic *B. Murrayana*, and others of characteristic *B. fruticosa*, Pack.; but there are many intermediate forms which make separation difficult, though perhaps there are other characters not yet noticed by which they can be distinguished.

A typical specimen from off Cape Mary Harmsworth has about six marginal spines on each side, larger avicularia to the marginal zoëcia; the central avicularia are shorter than in the *fruticosa* variety. The branches are composed of 6 or more zoëcia to a row. Another specimen from the same locality has 3-4 zoëcia to a row, marginal avicularia and a few marginal spines, some zoëcia having none. A small fragment also from the same place has 8-9 marginal spines. This is in a uni-bilateral condition, but is probably torn from a larger piece.

From near Wilczek Land, 127 fathoms, there is a *Bugula* with marginal avicularia, no bordering spines, two pairs of distal spines. The branches are not broad, and the zoëcia are often but loosely attached, and in several cases a zoëcium grows out laterally from the radicular disk. In one or two cases a tubular growth springs from the distal end of the zoëcium, and from the end of this elongated tube grows an ordinary zoëcium. In

most respects this resembles *B. Murrayana*, but in others it is like var. *fruticosa*.

Sections of a specimen from off Cape Mary Harmsworth showed 21 tentacles, whereas a specimen of var. *fruticosa* from off West Point gave 17 tentacles; specimens from Greenland of *B. Murrayana typica* had 18-20 tentacles. In this and the variety there are two lateral rosette-plates, and one distal plate with numerous pores.

In *Bugula* the rule is a row of small rosette-plates\* near the distal border, and from the entirely different mode of connection it is possible that this species will be ultimately removed from *Bugula*. In *Bugula* it is not usual for the avicularia to be median. The *Bugula hexacantha*, Ortmann, from Japan would seem to be *B. Murrayana*.

*Loc.* British seas, Scandinavia, Finland, Spitzbergen, Greenland, Barents Sea, Novaya Zemlya, Jan Mayen, Franklin Pierce Bay, lat. 79° 29' N. Japan?

Jackson-Harmsworth Exp.: Cape Mary Harmsworth, 53-93 fathoms.

##### 5. *BUGULA MURRAYANA*, var. *FRUTICOSA*, Packard.

In this variety the branches of the zoarium are usually narrower than in typical *B. Murrayana*, the marginal spines are absent, and the oral ones are often very slightly developed. There are no marginal avicularia, and the central ones are usually much less numerous than in typical *B. Murrayana*.

A specimen from off West Point, Northbrook Island, has two oral spines on each side, avicularia placed centrally below the area of the zoecia, but no marginal avicularia. There are 17 tentacles.

Another specimen from the same place, also from 2-3 fathoms, consists of four or more rows of zoecia. The outer zoecia have one outer spine, while the inner zoecia have two pairs of oral spines.

A specimen from off Cape Gertrude, 30 fathoms, has two small spines on the outer side of the zoecia, and one on the inner. There are no avicularia in this specimen.

*Loc.* Spitzbergen, Finland, Kara Sea, Davis Straits, Labrador, Gulf of St. Lawrence; Franz-Josef Land, lat. 79° 55' N., long. 51° 0' E. (*Ridley*).

\* See Levinsen, Danske Dyr (Mosdyr), pl. i. f. 40.



Jackson-Harmsworth Exp.: off Northbrook Island, 2-3 fath.; off Cape Gertrude, 30 fath.

6. *BUGULA HARMSWORTHII*, sp. nov. (Pl. 7. fig. 13, Pl. 8. fig. 1.)

The three lower zoecia retain the primary character and are elongate, tubular, slightly trumpet-shaped, expanding upwards; aperture terminal with ten spines round the margin, two radicles arising from near to the base. The mature zoecia are biserial, have two spines at each corner, an area covering about two-thirds of the front of the zoecium, and a large avicularium placed a little more than a quarter of the length of the zoecium from the top. Ovicell unknown.

This was at first taken for *B. avicularia*, L., but differs in having four spines, the area is shorter, the avicularia are somewhat longer, and the primary zoecia are not the same. Unfortunately there was only one piece, so that it was not advisable to cut any sections.

Lorenz gives *B. avicularia*, L., from Jan Mayen.

*Loc.* From off Cape Mary Harmsworth, 53-93 fath.

7. *SCRUPOCELLARIA SCABRA* (*Van Ben.*). (Pl. 7. figs. 14-16.)

*Cellarina scabra*, Van Beneden, Bull. Acad. Roy. de Belgique, vol. xv. pt. i. p. 73, figs. 3-6 (1848).

*Scrupocellaria Delili*, Alder, On New Brit. Polyzoa, Micr. Journ. n. s. vol. iv. p. 107 (13), pl. iv. figs. 4-8.

*Cellularia scabra*, Smitt, "Krit. Fört." 1867, pp. 283 & 314, pl. xvii. figs. 27-34.

*Scrupocellaria scabra*, Norman, Q. Journ. Micr. Sc. n. s. vol. viii. p. 214 (3); Hincks, Brit. Mar. Polyz. p. 48, pl. vi. figs. 7-11; id. Ann. Mag. Nat. Hist. ser. 6, vol. iii. p. 427, pl. xxi. fig. 1.

All the Arctic specimens now examined have a very large scutum, resembling in this respect the form described by Hincks from Gaspé Bay (St. Lawrence), and which he says also occurs in Greenland, and it might be an advantage to separate them as a variety from the British forms. There are usually two spines to each zoecium, but occasionally three, and three spines to the zoecium at the bifurcation, and there sometimes is one vibraculum on the dorsal surface at the bifurcation. This is, however, often wanting; so that both Levinsen and I have referred to *S. scabra* as without any vibraculum at the bifurcation. In the same way, the large dorsal vibracula are frequently altogether wanting, so that whole colonies may be described as without

vibracula; but when a radicle occurs, and they are not frequent, there is usually a vibracular chamber nearly at right angles to the axis of the zoarium. The seta is broad at the base and is symmetrical. There are 16 tentacles.

In my paper on the *Cellulariidae*, I have shown that *S. scabra* is a northern form and *S. Delilii*, Aud., Mediterranean and from Madeira; and I have been unable to accept some of the synonyms given by Mr. Hincks and Miss Jelly, and there have also been some mistakes in giving the range of localities.

*Loc.* Spitzbergen, 6-150 fath.; Greenland, Finland, Novaya Zemlya, Kara Sea, Jan Mayen, Murman Sea; Franz-Josef Land, lat. 77° 55' N., long. 51° 0' E. (*Ridley*); Kola, Iceland, St. Lawrence (*Hincks*); Norway, North Sea, British seas, Davis Straits.

Jackson-Harmsworth Exp.: nr. Wilczek Land, 127 fath.; off Cape Mary Harmsworth, 53-93 fath.; off Cape Gertrude, 30 fath.

8. *SCRUPOCELLARIA TERNATA*, var. *GRACILIS* (*Smitt*). (Pl. 7. fig. 12.)

*Cellularia ternata*, var. *gracilis*, Smitt, "Krit. Fört." 1867, pp. 283 & 305, pl. xvi. figs. 14-24.

*Cellarina ternata*, var. *gracilis*, Verrill, Cont. Zool. Mus. Yale College, no. 43 (fide *Jelly*).

*Menipea gracilis*, Levinsen, Bryoz. Kara-Havet, p. 307 (3); Busk, Journ. Linn. Soc. vol. xv. p. 232.

*Menipea arctica*, Busk, Quart. Journ. Micr. Sc. vol. iii. p. 254, pl. i. figs. 4, 5, 6; Ridley, Ann. Mag. Nat. Hist. ser. 5, vol. vii. p. 444; Lorenz, Bry. von Jan Mayen, p. 83.

*Menipea ternata*, Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. x. p. 3; Bidentkap, Bry. von Ost-Spitzbergen, p. 613.

There has been considerable doubt as to the position of this form, for some authors, as Bidentkap, think, after the result of the examination of considerable material, that there should be no separation between *S. ternata* and *S. ternata* var. *gracilis*; others, as Levinsen and Busk, would make two species. Lorenz gave a table showing how his *S. arctica* varied with respect to spines, avicularia, and scutum.

The specimens from Franz-Josef Land are subject to very great variation: sometimes on the same colony the zoecia may be with or without a scutum, and this may be very minute or full-sized; the spines may be absent, or there may be one, two, or three. The median cell may be mucronate or plain, but often

the mucro only occurs on the younger zoëcia. In some positions the lateral spines are readily mistaken for a mucro.

There is one small specimen from off Cape Mary Harmsworth which has no lateral or suboral avicularia, no spines, no scutum, and the median cell is not mucronate. There are two moderate-sized specimens from off Günther Sound, on each of which I have found one lateral avicularium, while the other zoëcia are unprovided with them. These specimens have no scutum, and one lateral spine. On the other hand, there are specimens from Cape Mary Harmsworth in which both the scutum and lateral avicularia are fairly constant, and there is usually one lateral spine.

The absence of suboral avicularia seems to be general in the Arctic forms which I have had the opportunity of examining; and no authors except Busk and Smitt mention anterior avicularia on *S. gracilis*. Busk says: "anterior avicularium small, rare, and only (?) on the median zoëcium at a bifurcation." In specimens sent me from Varanger Fjord as *M. gracilis* var., there are a few anterior avicularia to the zoëcia at the bifurcation; but in these specimens there is to each zoëcium an extremely large scutum and very large elongate ovicells besides very long spines, and probably it should be separated specifically. In no other case have I seen anterior avicularia.

The radicle is attached to a raised chamber at the base of the zoëcium, and in the specimens examined there are many zoëcia to an internode.

Specimens from lat. 77° 55' N., long. 53° 20' E., and those from Varanger Fjord have 16 tentacles. Busk says 12 tentacles to his specimen from Franklin Pierce Bay. *S. elongata*, Sm., has 18 tentacles; *S. Smittii*, Norm., 15 tentacles.

There are two lateral rosette-plates to the entire side, and the distal wall has a number of small rosette-plates near the base. The mode of connection is similar to that obtaining in *Scrupocellaria*, and that genus must be extended to receive this portion of the *Menipea* (auct.). The only difference is that there are no vibraculæ, but this is also the case in some typical *Scrupocellaria*, and in others they are rare.

*Loc.* Spitzbergen, Greenland, Scandinavia, Kara Sea, Novaya Zemlya, Jan Mayen, Queen Charlotte Islands (*H.*), Labrador, Barents Sea, Franklin Pierce Bay; lat. 79° 55' N., long. 51° 0' E. (*Ridley*); lat. 79° 31' N., long. 63° 21' E., 230 met. (*Marenzeller*).

Jackson-Harmsworth Expedition: Günther Sound, 10 fath.; nr. Wilczek Land, 127 fath.; lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 20' E.$ , 130 fath.; off Cape Mary Harmsworth, 53-93 fathoms.

9. *SCRUPOCELLARIA SMITTII* (Norm.). (Pl. 7. figs. 8-11.)

*Menipea Smittii*, Norman, Q. Journ. Micr. Sc. n. s. vol. viii. p. 214 (3).

*Menipea ternata*, forma *duplex*, Smitt, "Krit. Fört." 1867, pp. 283 & 312, pl. xvi. figs. 25, 26.

*Menipea duplex*, Levinsen, Bry. fra Kara-Havet, Dijnphna-Togtets zool.-bot. Udbytte, 1886, p. 309, pl. xxvi. figs. 1-2.

*Menipea Smittii*, Kirchenpauer, Hydr. & Bryoz. p. 418, Die zweite deutsche Nordpolfahrt.

There are specimens from 50 miles N.W. of Cape Mary Harmsworth which I think must be put to this species, although there are a variable number of spines. In the younger part of the zoarium there is usually but one spine, while in the older part there are sometimes as many as six. The central spine in the zoecium at a bifurcation may be wanting, though in other cases there are, besides the central one, two pairs of spines. There is no scutum. The lateral and suboral avicularia are both fairly constant. In some specimens there are generally six zoecia in an internode, in others ten is about the usual number.

The most important character seems to be the position of the radicle chamber, which is inside the zoecium; whereas in *S. gracilis*, and in nearly all the other species, it is formed by a conical chamber outside the zoecial wall. These chambers are formed in all the zoecia, whether there is a radicle or not. Another very important character is that the articulation occurs beyond the distal end of the outer zoecium (fig. 8). Usually in *Scrupocellaria*, as in *S. scabra*, *S. gracilis*, &c., the articulation is below the area of the outer zoecium (fig. 14).

There are 15 tentacles.

It is unfortunate that Norman did not take the varietal name *duplex*, as was subsequently done by Levinsen, but as Norman first gave a specific name it seems the correct thing to retain that name.

This species is closely related to *M. Jeffreysii*, Norm.

Loc. Spitzbergen, 50 fath. (Smitt); East Greenland (Kirch.); Kara Sea, 50-76 fath. (Levinson).

Jackson-Harmsworth Exp.: 50 miles N.W. Cape Mary Harmsworth, 284 fath.

10. SCRUPOCELLARIA ELONGATA (*Smitt*).

*Cellularia scabra*, forma *elongata*, Smitt, "Krit. Fört." 1867, p. 284, pl. xvii. figs. 35, 36.

*Scrupocellaria scabra*, forma *elongata*, Bidekap, Bry. von Ost-Spitzbergen, p. 614.

There are two specimens from off Cape Mary Harmsworth, in one of which there is a distinct spinous process at each upper corner, and it was at first marked "bispinata;" in the other the spines are only found on some zoëcia. There is a small sub-oral avicularium to some zoëcia and there are small lateral avicularia, no vibracula; in the specimen in which the spines are most developed there are a few scuta as figured by Smitt; the ovicell is elongate with a line down the middle and an area on each side, the radicle starts from near the base of the zoëcium, the radicle-chamber being external; zoëcium at the bifurcation acuminate. The jointing is low down as in *Scrupocellaria ternata* var. *gracilis* (Pl. 7. fig. 12), and in this respect differs entirely from *S. Smittii*, Norm. (figs. 8, 9), and is also much stouter than *S. scabra*, van Ben. There are 18 tentacles.

*Loc.* Spitzbergen (*Sm.* & *Biden.*); Greenland, Finland (*Sm.*).

Jackson-Harmsworth Expedition: off Cape Mary Harmsworth, 53-93 fathoms.

11. SCRUPOCELLARIA PEACHII (*Busk*).

*Cellularia Peachii*, Busk, Ann. Mag. Nat. Hist. ser. 2, vol. vii. p. 82, pl. viii. figs. 1-4.

In a paper dealing with Cellulariidae\* I have stated my opinion that the genus *Cellularia* must be dropped, and that some species so placed belong to *Scrupocellaria*.

The differences between this and *Scrupocellaria ternata*, var. *gracilis*, Sm., seem but slight, but as yet I have not had the opportunity of making sections of this species. The radicle arises from a chamber at the base of the zoëcium.

*Loc.* British, Spitzbergen, Novaya Zemlya, Kara Sea, Murman Sea, Barents Sea, Labrador.

Jackson-Harmsworth Expedition: small specimen off Cape Mary Harmsworth, 53-93 fath.

Besides the species of Cellulariidae already mentioned, Smitt gives *Caberea Ellisii* from Greenland, and Levinsen mentions *Kinetoskias arborescens*, Kor. & Dan., from Kara Sea [and Nordgaard gives *Bicellaria Alderi*, B., from Spitzbergen; also *Menipea Normani*, Nordg., from off the coast of Norway].

\* Journ. Linn. Soc., Zool. vol. xxvi. p. 1.

12. *FLUSTRA CARBASEA*, Ell. & Sol.

Smitt considered that this occurs both unilaminate and bilaminate, but the latter form has been named *Flustra spitzbergensis* by Bidentkap\*. The specimens brought back by the Jackson-Harmsworth Expedition are all unilaminate, and have 23-24 tentacles.

*Loc.* Spitzbergen, Norway, Greenland; Jan Mayen, Jugor- and Matotschkin-Schaar; Gulf of St. Lawrence; British seas: Iceland; Rattegat v. Anhol.

Jackson-Harmsworth Expedition: Günther Sound, 10 fath.; off East Glacier on floe; Cape Flora, nr. Wilczek Land, 127 fath.

13. *FLUSTRA MEMBRANACEO-TRUNCATA*, Smitt.

This throws out many radicle processes, and undoubtedly what Nitsche and Hincks called "Thurmzoecia" are only these processes, and the appearance is often quite similar to the figures of these structures, though of course they only occur on the dorsal surface, whereas they have been figured as on the anterior surface.

There are 16 tentacles, and 3 distal rosette-plates and 6 lateral.

*Loc.* Spitzbergen, Greenland, Kara Sea, Kola, Jugor- and Matotschkin-Schaar, Norway. [Jan Mayen (*Nordgaard*).]

Jackson-Harmsworth Expedition: Cape Mary Harmsworth, 53-93 fathoms.

Besides the above two species of *Flustra*, the *F. securifrons*, Pall., has been found in the Kara Sea; the *F. serrulata*, Busk, in the Kara Sea, from West Greenland, and from Franklin Pierce Bay; *F. abyssicola*†, Sars, has been found off Novaya Zemlya.

14. *MEMBRANIPORA MONOSTACHYS*, Busk. (Pl. 8. fig. 3.)

*Membranipora monostachys*, Busk, Brit. Mus. Cat. pt. 2, p. 61, pl. lxx. figs. 1-4.

*Hippothoa rugosa*, Stimpson, Invert. of Grand Manan, 1863, Smithsonian Cont. p. 18, fig. 9.

A specimen from near Wilczek Land has the blind cells which were mistaken by Busk for avicularia, and they seem to be formed when growth is arrested by any cause, such as meeting a neighbouring branch. There are no spines, though there are indications of a central spine in some zoecia; and it is difficult to

\* Bryozoen von Ost-Spitzbergen, p. 617, pl. xxv. figs. 1, 2.

† I regret that when describing *F. separata*, Waters, from off Nova Scotia in the Suppl. Rep. of the 'Challenger' Polyzoa, Chall. Zool. vol. xxxi., I did not recognize that it was *F. abyssicola*, Sars.

know whether it should be placed with *M. monostachys*, B., or *M. catenularia*, Jam. The lower part of the zoecia is not contracted to the extent usual in *M. catenularia*; the margins, however, can scarcely be called thin and slope inwards. The surface of the zoecium is nearly smooth with but slight tendency to form ridges. The opercular flap is large and very noticeable in balsam specimens, as it is less transparent than the membrane covering the rest of the opesium.

There are 10 tentacles, while there are 12 in *M. pilosa*.

*Loc.* Jackson-Harmsworth Expedition: Günther Sound, 10 fath.; off Elmwood, 18 fath.; nr. Wilczek Land, 127 fath.

#### 15. MEMBRANIPORA LINEATA (L.).

*Membranipora lineata*, Hincks, Brit. Mar. Polyzoa, p. 143, pl. xix. figs. 3-6; Waters, Linn. Soc. Journ. vol. xxvi. p. 678, pl. xlvii. fig. 11, pl. xlviii. fig. 9. For synonyms compare Miss Jelly's Catalogue.

Although this is widely distributed in the Arctic seas, I have only seen small pieces, which could not be used for study.

There are 13 tentacles.

*Loc.* Britain, Florida, Azores, Scandinavia, Spitzbergen, Finland, Greenland, Iceland, Davis Straits, Labrador, Kara Sea, Novaya Zemlya, Barents Sea, Jan Mayen.

Jackson-Harmsworth Expedition: off Elmwood, 18 fath.; nr. Wilczek Land, 127 fath.; off glacier between Cape Gertrude and Cape Flora, about 127 fath.; off Cape Mary Harmsworth, 53-93 fath.; lat. 77° 55' N., long. 55° 25' E., 115 fath.

#### 16. MEMBRANIPORA ARCTICA (d'Orb.).

*Reptoflustrina arctica*, d'Orb. Pal. Fr. vol. v. p. 582.

*Membranipora Sophiae*, Busk, Q. J. Micr. Sc. vol. iii. p. 255, pl. i. fig. 7 (1855); Ridley, Ann. Mag. Nat. Hist. ser. 5, vol. vii. p. 446, pl. xxi. fig. 2.

*Membranipora lineata*, f. *Sophiae*, Smitt, "Krit. Fört." 1867, pp. 365 & 394, pl. xx. figs. 24, 25.

*Membranipora arctica*, Lorenz, Bry. von Jan Mayen, p. 85, pl. vii. fig. 1; Nordgaard, Bergens Museums Aarbog, 1894-5, p. 17; Bidentkap, Bry. Ost-Spitzbergen, p. 620.

In my paper on Membraniporidæ in this Journal, vol. xxvi. p. 680, I suggested that it would be better to retain the name *M. Sophiae* and keep *arctica* for the *Semiflustraria arctica* of d'Orbigny; but as Bidentkap had, about the time my paper was written, made a species *M. spitzbergensis* for the *Semiflustraria arctica*, we must follow him.

There are three *Membranipora* which received the name

*arctica* from d'Orbigny: first the above *Reptoflustrina arctica*, then in manuscript the *Semiflustrellaria arctica* (= *M. spitzbergensis*, Bidentkap). A specimen from Newfoundland (13705) so named in the Musée d'Hist. Naturelle, Paris, has a small, round, widely open avicularium like that in *M. flustroides*, H. There is also the *Reptoflustrella arctica*, d'Orb., which has a few stout spines, a bar to the ovicell, and a triangular avicularium above the ovicell. This may be *M. unicornis*, Flem.

In a specimen from the Gulf of St. Lawrence sent to me by Canon Norman as *M. Sophiae*, many of the zoecia, especially the younger, are entirely without any trace of spines, and the same condition is found in some zoecia in the Franz-Josef Land specimen. Hincks has described from the Houston Stewart Channel (Queen Charlotte Islands) *M. Sophiae* form *matura* \*.

*Loc.* Spitzbergen, 10-30 fath.; Greenland, Jan Mayen, Kola, Norway, Assistance Bay (*Busk*); Gulf of St. Lawrence (in my coll.); Franz-Josef Land, lat. 79° 55' N., long. 51° 0' E. (*Ridley*); Norway.

Jackson-Harmsworth Expedition: off Elmwood  $\frac{2}{3}$  mile, 18 fath.; nr. Wilczek Land, 127 fathoms.

#### 17. MEMBRANIPORA SPINIFERA, Johnst.

Some small specimens from Günther Sound are placed under *M. spinifera*, though in some respects they seem to be intermediate between *M. spinifera*, Johnst., and *M. cymbæformis*, Hincks. The spines, about 8-10, are more delicate than in my specimen of *M. cymbæformis* from the Gulf of St. Lawrence.

The lamina to which Mr. Hincks referred does not exist in the specimen of *cymbæformis* in my collection, from Gulf of St. Lawrence, as can be easily seen in a piece boiled in caustic potash nor is it found in the present form.

*M. spinifera*, Johnst., is mentioned from the Barents Sea by Vigelius, and from the description this agrees with the specimens from Günther Sound, 10 fathoms. *M. cymbæformis* has been recorded from Jan Mayen (*Lorenz*); Kara Sea (*Levinsen*); Davis Straits, Labrador, and Gulf of St. Lawrence (*Hincks*); Spitzbergen (*Bidentkap*).

#### 18. MEMBRANIPORA MACILENTA, Jullien. (Pl. 8. fig. 10.)

*Membranipora macilenta*, Jullien, Bull. Soc. Géol. France, vol. vii. p. 25, pl. xvii. fig. 62, 1882.

Specimens growing on *Mytilus*-shell from nr. Wilczek Land,

\* Ann. & Mag. Nat. Hist. ser. 5, vol. x. p. 9, pl. xx. fig. 2.



127 fathoms, have large zoëcia with very thin walls and an avicularium with triangular mandible at each upper corner. There is no ovicell. As far as can be seen, it agrees with Jullien's species from the North of Spain, and is much like *Membranipora membranacea* with the spinous process developed into avicularia.

There are 18 tentacles.

Besides the *Membraniporæ* referred to in this paper, *M. craticula*, Alder, is said to have been found off Jan Mayen (Lorenz), and Franz-Josef Land (Ridley), Kara Sea, Novaya Zemlya, West Greenland, and Davis Straits. *M. Flemingii*, Busk, from Jan Mayen and West Greenland. *M. armifera* from the Gulf of St. Lawrence. *M. trifolium*, S. Wood, from Jan Mayen. [*M. cornigera*, Busk, from Bear Island (Nordgaard).]

19. CRIBRILINA PUNCTATA (Hassall). (Pl. 8. fig. 22.)

*Escharipora punctata*, Smitt, "Krit. Fört." 1867, p. 4, pl. xxiv. figs. 4-7.

The species brought back by the Jackson-Harmsworth Expedition is no doubt the species figured by Smitt, but it seems exceedingly doubtful if this is the same as the British species, and therefore I only refer to Smitt; and not having had the opportunity of examining many specimens of *C. punctata* I hesitate to give a new specific or varietal name, especially as the Franz-Josef Land specimens are very fragmentary and not sufficient for thorough examination.

The difference consists in the very wide ovicell, which is often almost concealed; and although Hincks speaks of the ovicell being subject to considerable variation, the difference between this very wide ovicell and the rather narrow ovicell of the ordinary British form is so very great, that until the links have been carefully studied we may doubt the identity.

It is mentioned as occurring off Jan Mayen, but as Lorenz does not give any particulars we cannot judge which form he had before him.

This species is of considerable interest from the fact that it occurs of the same size and with the same characters on a specimen of *Hornera lichenoides*, Pont., said to be from lat. 74° S. and long. 172° E., 330 fath., and to have been dredged by Sir John Ross in his Antarctic expedition. Mr. Busk mentions and had named the *Hornera* and also a piece of *Escharoides Sarsii*, Smitt, from the same dredge; but the *Cribrilina punctata*, Hass., had not been determined or mentioned when Mr. Kirkpatrick kindly

allowed me to examine the specimens in the British Museum collections.

Mr. Busk, however, in the Journal of this Society (vol. xv. p. 237), when describing Arctic *Escharoides Sarsii*, Sm., says it was collected in the Antarctic by the 'Erebus' and 'Terror,' "and was accompanied in the same collection by two other Arctic species." That a single haul so far south—in fact the farthest south from which any Bryozoa have been found—should furnish three of the commonest Arctic species, two of which have probably not been found outside the Arctic regions, seems so strange that we must pause and consider if there is no possibility of a mistake. This would be stronger proof of bipolarity of species than has yet been brought forward, and as much as the most ardent believers in the theory could expect.

Unless the present Antarctic expeditions should bring back some of these species, we shall be justified in thinking that there has been some change of label or exchange of box. As Sir John Ross had been in the Arctic regions, there is the possibility of this exchange having occurred on board the ship, or it may have happened subsequently in Mr. Busk's hands.

There are several specimens of mites in the *Escharoides*, and although the probability was so great that their origin was London, I asked my friend Mr. A. D. Michael if they could throw any light upon whether the Bryozoa came from the Arctic or Antarctic. He informed me that the specimens were immature *Glyciphagus domesticus*, de Geer, which is cosmopolitan, and therefore it does not help to settle the point. Mr. Michael informs me that this species had been found by the Jackson-Harmsworth expedition on the rocks some distance from the station, and that a drawing had been made of it at the time. Often specimens of Bryozoa are so full of diatoms that a question of doubtful origin could be settled by an examination of sections, but unfortunately there do not seem to be either foraminifera or diatoms to give us the geographical origin.

The occurrence of this *Cribrilina* identical with the Arctic form is of more importance than that of either *H. lichenoides* or *E. Sarsii*, being more highly differentiated, or at least having more distinctive characters.

Loc. Bohus Bay (*Smitt*); littoral, Norway (*Smitt*); Gullmaren, 7-10 fathoms.

Jackson-Harmsworth Exp.: Lat. 77° 55' N., long. 53° 16' E., 130 fathoms.

20. *CRIBRILINA ANNULATA* (Fab.). (Pl. 8. fig. 21.)

Round the distal border there are, in the specimen from Franz-Josef Land, calcareous processes in place of the spines.

*Loc.* Spitzbergen, Jan Mayen, Kara Sea (*Levinsen*), Finland, New Brunswick, Gulf of St. Lawrence, Labrador, Scandinavia, British Isles, Denmark.

Jackson-Harmsworth Exp.: off glacier between Cape Flora and Cape Gertrude, about 30 fathoms.

I have already shown the geographical distribution of *Flustra*\* and *Membranipora*†, and we now seem to be sufficiently well acquainted with *Cribrilina* to give a similar list for this genus.

Arctic.....	<i>C. ANNULATA</i> ‡, Fab., <i>PUNCTATA</i> , Gray, <i>nitido-punctata</i> , Sm., <i>scutulata</i> , Busk (? <i>Cribrilina</i> ).
British .....	<i>ANNULATA</i> , <i>PUNCTATA</i> , <i>RADIATA</i> , Aud., <i>FIGULARIS</i> , Johnst., <i>GATTYÆ</i> , Busk.
Mediterranean.	<i>RADIATA</i> , <i>FIGULARIS</i> , <i>GATTYÆ</i> , Balzaci, Aud., <i>SETOSA</i> , Waters.
North Atlantic.	<i>PUNCTATA</i> , <i>RADIATA</i> , Balzaci, <i>SETOSA</i> .
South Atlantic.	<i>RADIATA</i> , <i>MONOCEROS</i> , Busk, <i>latimarginata</i> , Busk.
South African..	<i>labiosa</i> , Busk.
Australasian ...	<i>RADIATA</i> , <i>MONOCEROS</i> , <i>PHILOMELA</i> , B., <i>acanthoceros</i> , MacG., <i>setirostris</i> , MacG., <i>speciosa</i> , Hincks, <i>tubulifera</i> , H., <i>clithridata</i> , Waters.
South Indian Ocean.	<i>RADIATA</i> , <i>philomela</i> var. <i>adnata</i> , Busk.
North Pacific...	<i>MONOCEROS</i> , <i>hippocrepis</i> , Hincks, <i>furcata</i> , H.
South Pacific...	<i>MONOCEROS</i> .
Japan .....	<i>PHILOMELA</i> , Busk, <i>reniformis</i> , Ortmann.

21. *SCHIZOPORELLA CRUSTACEA* (Smitt). (Pl. 8. figs. 11-13.)

*Myrionozoum crustaceum*, Smitt, "Krit. Fört." 1867, p. 18, pl. xxv. figs. 88-91; Ridley, Ann. Mag. Nat. Hist. ser. 5, vol. vii. p. 448; Bidentkap, Bry. Ost-Spitzbergen, Zool. Jahrb. vol. x. p. 622.

*Leieschara crustacea*, Levinsen, "Bry. f. Kara-Havet," *Dijmphna* Togtets zool.-bot. Udbytte, 1886, p. 317 (13).

*Schizoporella crustacea*, Lorenz, Bry. von Jan Mayen, p. 87, pl. vii. fig. 2.

\* Journ. Roy. Micr. Soc. 1896, p. 286.

† Journ. Linn. Soc., Zool. vol. xxvi. p. 664.

‡ Species printed in small capitals occur from a second region.

*Lepralia plana*, Dawson, Polyzoa of the Gulf of St. Lawrence, Rep. Canadian Geol. Surv. 1858, p. 256.

*Myrizoum planum*, Hincks, Ann. Mag. Nat. Hist. ser. 6, vol. ix. p. 157.

*Myrizoum* is the genus of Donati of which the type is *M. truncatum*, and it, together with *M. coarctum* and *subgracile* and the genus *Haswellia*, has very long pore-tubes, and the centre of the zoarium of the erect species has a spongy structure. *Schizoporella crustacea* has longer pores than most of the Bryozoa, and they open diagonally, causing the open ornamentation; but the value of a character like this is difficult to estimate, as it is only one of degree, short pores occurring in a great part of the Chilostomata. The shape of the aperture corresponds with that of *Myrizoum coarctum* and *M. subgracile*.

I do not consider this species the same as *S. incisa*, M.-Ed.; and therefore probably the fossil determined by Neviani as *S. crustacea* should be placed elsewhere. The description of *L. plana*, Dawson, was too insufficient to justify the adoption of that name.

There are 15 tentacles.

*Loc.* Greenland, 14-35 fath. (*Busk*); Spitzbergen, 10-80 fath. (*Bidenkap*); Kara Sea, 30-85 fath.; Kola; Jan Mayen, 15-180 metres (*Lorenz*); Gulf of St. Lawrence; lat. 79° 55' N., long. 51° 0' E. (*Ridley*); Finland.

Jackson-Harmsworth Exp.: off Elmwood, 18 fath.; Günther Sound, 10 fath.

22. SCHIZOPORELLA HARMSWORTHII, nom. nov. (Pl. 9. figs. 10-12.)

*Eschara Legentilii*, Aud., forma prototypa, Smitt, "Krit. Fört." 1867, pp. 10 & 81, pl. xxiv. figs. 47, 48.

*Schizoporella cincta*, Hincks, var., Hincks, Ann. Mag. Nat. Hist. ser. 6, vol. ix. p. 154, pl. viii. fig. 2.

The imperforate area immediately below the oral aperture is often depressed, giving a characteristic appearance to the zoecium; in other cases it is raised and carries an avicularium. The pits on the surface are very deep and are perforated at the bottom.

The suboral glands of this species are very interesting, as they arise from the upper part of the tentacular sheath, and the gland is attached to the sheath for some little distance. The glandular cells are distinctly nucleated, and the interior of the gland contains a nearly homogeneous mass which does not stain. From

this I think we may conclude that the suboral and avicularian glands are homologous. In this species, as well as in those alluded to in the subsequent part of this paper, it appears that the gland is emptied close by the wall of the tentacular sheath when the polypide is extruded; and we have seen that the avicularian gland of *Lepralia foliacea*\*, Ell. & Sol., is attached in a somewhat similar manner to the sheath of the avicularium. The contents of the avicularian glands of *Porella acutirostris*, Smitt, are also a homogeneous mass; and we can scarcely doubt any longer that these glands are excretory organs.

Kirchenpauer has given the name *Lepralia Smittii* to *Escharella Legentilii*, forma *prototypa* of Smitt, but as Smitt figures distinct forms under his *prototypa* the name cannot be retained. Possibly Smitt had *Lepralia borealis*, Waters, before him as well as the present form.

*Loc.* St. Lawrence (*H.*); Spitzbergen (*Sm.*); Greenland (*Sm.*).

Jackson-Harmsworth Exp.: Lat. 77° 55' N., long. 53° 16' E., 130 fath.; off glacier between Cape Flora and Cape Gertrude, about 30 fath.

23. *SCHIZOPORELLA* *ELMWOODIÆ*, sp. nov. (Pl. 9. figs. 1 & 13.)

A dry specimen encrusting a piece of basalt from off Elmwood, 18 fathoms, seems to be new.

The zoecia are broadly ovate, considerably raised, and distinctly separated, with the surface finely granular, and with pores scattered over the surface. The aperture is close to the distal edge, and has a distinct sinus. The operculum is granular, and instead of having two muscular dots, as in most *Schizoporellæ*, has a muscular ridge some distance from the border, and must perhaps ultimately be put in a separate division of the *Schizoporellæ* on that account. The ovicell is much raised, very broad and granular; and is not closed by the operculum. In a few zoecia there is a triangular avicularium on one side lower than the aperture. There are sometimes irregular elevations on the two sides of the zoecia.

Besides the *Schizoporellæ* brought back by this Expedition, *S. candida*, Stimpson; *S. linearis*, Hass.; *S. biaperta*, Mich.; *S. sinuosa*, B.; *S. limbata*, Lorenz; *S. stylifera*, Levinsen; *S. auriculata*, Hass., are said to have been found in the Arctic regions.

\* Waters, "Observations on Gland-like Bodies in the Bryozoa," Linn. Soc. Journ., Zool. vol. xxiv. p. 272.

## MYRIOZOOM.

Whether this genus should be retained is very questionable, but for the present it is more convenient to keep the name for *M. coarctum*, Sars, and *M. subgracile*, d'Orb., remembering that in descriptive papers we may often have to use generic divisions which we are aware may ultimately be altered.

The genus was created by Donati with *M. truncatum*, Pall., as the type, and it has been based to a large extent upon the zoarial shape of growth; and the definitions given by Donati, Sars (*Leieschara*), d'Orbigny, and Smitt would not justify its retention. The aperture of *M. truncatum* is nearly round, while those of *M. coarctum* and *subgracile* are schizoporellidan, with a well-marked sinus.

There is, however, one character which may be of great classificatory value, and that is the long tubes, which I have called pore-tubes, from the surface to the interior, and from one zoecium to another, causing the spongy structure of the zoarium. These tubes have a disk near the junction with the zoecium; and in the middle of the axial tubes, which are often very long, there are similar disks (Pl. 9. fig. 6 *d*; fig. 7 *d*). The shell-structure is terminated by a membrane (fig. 8 *b*) perforated by these pores; but over this, as in the greater part of the Chilostomatous Bryozoa, there is another fairly thick and somewhat chitinous membrane (fig. 7 *a*) continuously covering the zoarium. The cell-contents of the tubes attach themselves to this by delicate threads (fig. 8); and thus by this connection there may be an interchange between the sea-water and the contents of the tubes, which again are in indirect communication with the contents of the zoecia. Although in other genera these tubes are not developed to the same length, the structure is very similar.

In figures 6, 7 (Pl. 9), drawn to explain these tubes, the way in which the diaphragm is folded when the polypide is retracted is also shown. This folding, which at first I called an opercular fold, occurs in a similar position in most of the Chilostomata, but the appearance of this diaphragm varies much in different species and at different times. It is attached to the tentacular sheath, and is, as described by Nitsche\*, a strong sphincter which can completely close the tentacular sheath-cavity. The central

\* Nitsche, "Ueb. Anat. u. Entw. von *Flustra membranacea*," Zeits. f. wiss. Zool. vol. xxi. p. 17.

opening seems to be a chitinous ring in *Lepralia sincera*, Sm., from which there are rays of muscular tissue, and there are concentric rings, also no doubt contractile.

Pergens\* speaks of the tentacular sheath having four closeable openings: (1) the opercular opening, (2) Nitsche's diaphragm, (3) oral opening, (4) anal opening; but this seems to me more complicated than is the case, and though the diaphragm may in some cases be a little distance from the external opening, yet it seems enough to speak of the opening through the diaphragm and the anal opening; and I cannot follow Pergens in considering that any opening has been found from the tentacle-sheath into the body-cavity.

*Myrionozoum ovum*, Smitt, will be *Stichoporina* or *Fedora*; and *M. marionensis*, Busk, is the only species determined as *Myrionozoum* from the Southern hemisphere.

#### 24. MYRIONOZOU M COARCTUM (Sars). (Pl. 9. figs. 2, 3.)

*Cellepora coarcta*, M. Sars, Nyt Mag. f. Naturv. vol. vi. p. 148 (28), 1850?

*Leieschara coarcta*, M. Sars, Beskr. N. Poly. 1862, p. 155 (17).

For synonyms of Smitt, Busk, Hincks, Lorenz, see Miss Jelly's Catalogue.

*Myrionozoum coarctum*, Bidentkap, Bryozoen von Ost-Spitzbergen, Zool. Jahrb. vol. x. p. 621; Hennig, Öfvers. af K. Vetensk.-Ak. Förh. 1896, p. 357.

This species does not appear to have been figured, saving the section given by Smitt. The semicircular avicularia are placed in a row between the zoecia and vary considerably in size, so that the avicularian aperture may be as large as the oral aperture. There are 16 tentacles, as in *M. subgracile*, d'Orb., while in *M. truncatum*, Pall., there are about 26 or 27 tentacles. Pergens speaks of 33, but I have not seen so many, and sections he sent me correspond with those I made from material brought back from Naples. One of the pieces is about two inches long, and has clearly been broken off a much larger one. The branches anastomose at an angle of about 60 degrees and more, and some branches grow out nearly at right angles from the main branches.

*Loc.* Spitzbergen, 19-80 fath. (*Smitt*), 40-95 fath. (*Bidentkap*); Kola, Norway; Jan Mayen, 140-400 metres (*Lorenz*); Davis

\* "Untersuch. an Seebryozoen," Zool. Anzeiger, 1889, p. 4.

Straits, 100 fath. (*Hincks*); Murchison Sound, 45 fath. (*Hennig*); Finland? (*Sars*).

Jackson-Harmsworth Expedition: about 40 and 50 miles off Cape Mary Harmsworth, 234 fathoms.

25. *MYRIOZOUM SUBGRACILE*, d'Orb. (Pl. 9. figs. 4-8.)

*Myrionozoum subgracile*, d'Orb. Pal. Franç. vol. v. p. 622; Smitt, "Krit. Fört." 1867, pp. 18 & 119; Hincks, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 106; D'Urban, Ann. Mag. Nat. Hist. ser. 5, vol. vi. p. 274; Ridley, Ann. Mag. Nat. Hist. ser. 5, vol. vii. p. 448; Waters, Journ. Roy. Micr. Soc. vol. ii. p. 390, pl. xv. fig. 5; Bidentkap, Bry. von Ost-Spitzbergen, Zool. Jahrb. vol. x. p. 622.

*Myrionozoum pulchrum*, Ortmann, Die Japanische Bryozoen-fauna, Arch. f. Naturgesch. 1889, p. 53, pl. iv. fig. 8.

In the Franz-Josef Land specimens the subcircular avicularium is usually slightly above the oral aperture to one side, and placed diagonally. In the Japanese specimen in my collection the avicularium, though slightly lower, is similarly placed, but it is only found to a few zoecia.

There are 16 tentacles, as in *M. coarctum*, Sars; and the two species are very similar, though it seems that they should be separated on account of the difference in size and position of the avicularium. We cannot be absolutely sure which of the two species Sars and other writers previous to Smitt had before them.

Some of d'Orbigny's specimens from Newfoundland in the Musée d'Hist. Nat. belong to this species, but I had not time, when in Paris, to examine whether any of the specimens might be *M. coarctum*.

*Loc.* Spitzbergen, 19-80 fath. (*Smitt*), 55-65 fath. (*Bidentkap*); Kara Sea, Greenland, Barents Sea, Murman Sea (*D'Urban*); Davis Straits, 100 fath. (*Hincks*); Franklin Pierce Bay (*Busk*); Newfoundland (*d'Orb.*); lat. 75° 36' N., long. 57° 6' E. (*Marenzeller*); Japan.

Jackson-Harmsworth Exp.: off Elmwood, S.W. 1½ mile, 26 fath.; off glacier between Cape Flora and Cape Gertrude, about 30 fath.; Cape Gertrude, 30 fath.; nr. Wilczek Land, 127 fath.; off Cape Mary Harmsworth, 53-93 fath.

26. *HIPPOTHOA EXPANSA*, Dawson. (Pl. 8. fig. 19.)

*Hippothoa expansa*, Hincks, Brit. Mar. Polyzoa, p. 291, pl. i. fig. 1, which see for synonyms.

The ovicelligerous zoecia are usually shorter than the others,



and the aperture has the lower edge nearly straight, so that the operculum is similar to that of the ovicelligerous zoëcia of *Hippothoa hyalina*, L. All the specimens from Elmwood were dry, and there was no material for cutting sections. The *H. divaricata* has the aperture of the ovicelligerous and ordinary zoëcia similar, both having a broad sinus.

*Loc.* Gulf of St. Lawrence, Labrador, Maine, Queen Charlotte Islands; Greenland, 57 fath.; Shetland, 100 fath.

Jackson-Harmsworth Exp.: off Elmwood, 18 fath.

27. HIPPOTHOA HYALINA, L. (Pl. 8. figs. 16-18.)

*Mollia hyalina*, forma *hyalina*, Smitt, "Krit. Fört." 1867, p. 16, pl. xxv. figs. 84, 85. Compare list of synonyms in Hincks's Brit. Mar. Poly. p. 271, and Miss Jelly's Catalogue.

Norman\* considers this should be placed in the genus *Celleporella* of Gray, and states that it was the only species in the genus as described by Gray, and that therefore the genus *Diazeuxia* of Jullien is merely a synonym. It would be unfortunate if the laws of priority obliged us to put the latter under *Celleporella*, as it has been used in another sense by both Hincks and Norman.

However, the reasons for separating *Diazeuxia* from *Schizoporella* are based upon the reproductive characters mentioned by Jullien. The female zoëcia carrying the ovicell are usually very short, and according to Jullien possess no polypide. I have, however, some specimens in which these zoëcia are about the same size as the others. There are also very minute zoëcial cells with very small opercula (fig. 16), which Jullien says are male zoëcia without polypides; and these may occur on the front of an ordinary zoëcium, as in specimens from California, or there may be one at each side of the aperture, or they may occur scattered between other zoëcia.

*Hippothoa* has usually short ovicelligerous zoëcia; and if we are to attach most weight to the reproductive organs, then there seems little doubt that the right place for this species is *Hippothoa*. The shape of the aperture of the ordinary zoëcia is similar throughout the genus. Jullien considers that larval peculiarities and other characters justify this being placed in a family *Diazeuxidæ*, and probably family distinction may have to be made. The small specimens available have not been sufficient for cutting satisfactory sections.

\* Ann. & Mag. Nat. Hist. ser. 6, vol. xiii. p. 129.

Barrois shows that the larva, although of the "*Escharina*-" type, differs from others, and is in fact simpler, resembling rather closely that of his *Mollia granifera* (*Microporella impressa*, Aud.). It has four pairs of oculiform points, and apparently from his figures two single ones; that is to say, these pigment-cells are more numerous than is usually the case. There is no ciliated crown.

In the Franz-Josef Land specimens there are 14 tentacles; but Jullien and Hincks mention 12 tentacles.

*Loc.* Cosmopolitan. In the Arctic regions—Spitzbergen, Greenland, Jan Mayen, Kara Sea, Barents Sea, Scandinavia. It also occurs in South America, Australia, and the Kerguelen region.

Jackson-Harmsworth Exp.: Günther Sound, 10 fath.; off Cape Mary Harmsworth, 53-93 fath., 7/8/97, with ova and ovicells.

## 28. PSEUDOFUSTRA PALMATA (Sars). (Pl. 8. figs. 7-9.)

*Eschara palmata*, Sars, Forh. i Vidensk. Selsk. 1863, p. 146 (8).

*Escharella palmata*, Smitt, "Krit. Fört." 1867, pp. 10 & 77, pl. xxiv. figs. 42-46; Whiteaves, Rep. on Gulf of St. Lawrence, 1874, p. 12; Levinsen, Bry. fra Kara-Havet, Dijnphna-Togtets zool.-bot. Udb. p. 318 (14), pl. xxvii. fig. 3; Lorenz, Bry. von Jan Mayen, p. 91; Marenzeller, Denks. K. Akad. Wissensch. Wien, vol. xxxv. p. 388.

*Flustra solida*, Stimpson, Mar. Inv. Grand Manan, 1853, Smithsonian Cont. p. 19, fig. 12; Hincks, Ann. & Mag. Nat. Hist. ser. vol. vi. p. 282, pl. xv. figs. 2, 3, and ser. 6, vol. ix. p. 149, pl. viii. fig. 1.

*Eschara solida* Vergelius, Nederl. Arch. f. Zool., Suppl. B. p. 15, figs. 2, 3.

*Pseudoflustra solida*, Bidentkap, Bry. von Ost-Spitzbergen, Zool. Jahrb. vol. x. p. 618.

It is difficult to know where this should be placed. *Eschara* has been discarded, *Escharella* of Smitt is not the same as *Escharella* of d'Orbigny, and Smitt's *Escharella* corresponds now for the greater part with *Smittia* (Hincks). The name *Pseudoflustra* is unfortunate, the foliaceous growth having suggested *Flustra*; but the entirely different aperture, the characters of avicularium and ovicell, besides the rosette-plates near the basal wall, all suggest the removal from *Flustra*, and the relationship is in the direction of *Lepralia*. The genus *Cyelicopora*, Hincks, has a nearly round aperture, though the operculum has the lower edge more or less straight, in some respects resembling the operculum

of *Membranipora*; but the genus is described as without avicularia, though we have often seen that it is dangerous to make the absence of avicularia a generic character: in fact negative characters are not often to be relied upon. At present there does not seem sufficient reason for placing the *palmata* of Sars under *Cyclicopora*, and therefore the name given by Bideknapp is retained. Stimpson may have had this species before him; but as the description appears quite insufficient for recognition, and might almost as well be applied to some other species, it seems only right to retain the name given by Sars, as he clearly described it.

The form which Hincks described (*loc. cit.* pl. viii. fig. 1) with a distinct sinus in the aperture, and with semicircular avicularia, can hardly remain with this species.

There are two large rosette-plates near the basal wall and several (6-8) on the lateral wall. I have not found any oral or avicularian glands. There are 18 tentacles. A specimen from lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 20' E.$ , has the peristome raised at the side, but this does not occur in any of the other specimens.

The zoaria, according to Vigeliu8, may be uni- or bilaminar, but I have only seen them bilaminar.

*Loc.* Spitzbergen (*Smitt & Bideknapp*), Greenland, Kola (*Sm.*), Barents Sea (*Hincks*), Matotschkin Schaar (*Sm. & Stuxb.*), Kara Sea, Jan Mayen (*Lorenz*); lat.  $79^{\circ} 13' N.$ , long.  $63^{\circ} 21' E.$ , 230 met. (*Marenzeller*); Norway (*Nordgaard*); St. Lawrence (*Hincks*); New Brunswick (*Stimpson*).

Jackson-Harmsworth Exp.: off glacier between Cape Flora and Cape Gertrude, 30 fath.; off Cape Gertrude, 30 fath.; lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 20' E.$ , and long.  $53^{\circ} 16' E.$ , 130 fath.

## 29. *LEPRALIA SINCERA* (*Smitt*). (Pl. 8. fig. 2.)

*Discopora sincera*, Smitt, "Krit. Fört." 1867, p. 28, pl. xxvii. figs. 178-180.

*Lepralia sincera*, Hincks, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 102, pl. xi. fig. 2; Lorenz, Bry. von Jan Mayen, p. 88; Hennig, Cefvers. Vetensk.-Ak. Förh. 1896, p. 357.

*Discopora reticularis*, Van Beneden, Recherches sur les Bry. de la Mer du Nord, Bull. Acad. Roy. Belg. vol. xvi. p. 652, pl. ii. figs. 15-18.

*Hemeschara sincera*, Busk, Journ. Linn. Soc., Zool. vol. xv. p. 237.

*Mucronella sincera*, Nordgaard, Bergens Mus. Aarbog, 1894-5, p. 29, pl. i. fig. 6; Bideknapp, Bry. von Ost-Spitzbergen, Zool. Jahrb. vol. x. p. 625.

There are 22 tentacles and two distal rosette-plates. I am unable to find any oral glands, and do not see any ovaria or testes in the sections prepared.

The aperture and operculum vary somewhat from typical *Lepralia*; but there does not seem sufficient reason for removing it from *Lepralia* at present.

*Loc.* Spitzbergen, 19–60 fathoms (*Smitt*); Greenland (*Hennig*); Kara Sea; Jan Mayen, 160–270 metres (*Lorenz*); Finland, Davis Straits (*Hincks*); Baffin's Bay, 175 fath., Franklin-Pierce Bay, Smith's Sound, 13 fath. (*Bush*); Inglefield Gulf, 25 fath., and Northumberland Island, 20 fath. (N.W. Greenland) (*Hennig*).

Jackson-Harmsworth Exp.: off Cape Mary Harmsworth, 53–93 fathoms.

### 30. *LEPRALIA BOREALIS*, sp. nov. (Pl. 8. figs. 4–6.)

Zoöcia encrusting, rhombic, very distinctly separated by divisional lines, row of pores round the border, surface granular; median suboral avicularium with small round mandible, large raised ovicell with numerous pores; fairly thick operculum nearly straight on the lower edge; oral aperture subcircular, with a small lateral denticle on each side, four lateral rosette-plates near the basal wall. There are 18 tentacles and two oral glands, but there do not appear to be any avicularian glands.

This in many respects resembles some of Smitt's figures of *Escharella Legentilii* var. *prototypa*, but no doubt Smitt placed several distinct species under *Legentilii*. This differs from *Smittia reticulata*, MacG., in the shape of the operculum, and in having no central denticle (lyrula). The mandible has a large median lucida, and two large clear spots, and is somewhat of the *Porella*-type. The avicularian chamber extends to each border.

*Loc.* Lat. 77° 55' N., long. 53° 16' E., 130 fathoms.

### 31. *LEPRALIA CRUENTA*, *Norm.*

*Lepralia cruenta*, Norman, Ann. Mag. Nat. Hist. ser. 3, vol. xiii. 1864, p. 7 (88).

*Discopora cruenta*, Smitt, Öfvers. Vetensk.-Ak. Förh. 1871, p. 1127, pl. xxi., and 1878, p. 23.

*Schizoporella cruenta*, Hincks, Brit. Mar. Polyzoa, p. 270, pl. xxx. fig. 5; id. Ann. Mag. Nat. Hist. ser. 5, vol. vii. p. 449, pl. xxi. fig. 4; id. ibid. ser. 5, vol. xiii. p. 211; id. ibid. ser. 6, vol. ix. p. 153, pl. viii. fig. 5; Ridley, Ann. Mag. Nat. Hist. ser. 5, vol. vii. p. 449, pl. xxi. fig. 4.

*Mucronella cruenta*, Nordgaard, Bergens Mus. Aarbog, 1894-5, p. 30.

*Porina ciliata*, forma *dura*, Smitt, "Krit. Fört." 1867, pp. 6 & 58, pl. xxiv. fig. 17.

*Mucronella spinulifera*, Hincks, Ann. Mag. Nat. Hist. ser. 6, vol. iii. p. 431, pl. xxi. fig. 3.

*Monoporella spinulifera*, Hincks, Ann. Mag. Nat. Hist. ser. 6, vol. ix. p. 152.

The dry specimens on *Balanus*, from off Elmwood, are reddish black with fairly large zoëcia irregularly undulated, and more nearly resemble Smitt's than any of the other figures; and Hincks may be right in considering that the *M. spinulifera* is the species described by Smitt, and that it is not the same as the *Lepralia cruenta* of Norman. The peristomial opening in the older zoëcia is subtriangular, having a kind of sinus, and resembles in appearance that of *Escharoides Sarsii*, Sm., and may easily have been taken for adnate *E. Sarsii*. The younger zoëcia show the straight proximal edge to the aperture. The oral aperture in older zoëcia is very much depressed, and is not visible from the front; and when Hincks and Ridley speak of a sinus they could only have seen the peristomial opening. The operculum has a straight lower edge, and is fairly characteristic Lepralian (woodcut, p. 78, fig. 1). There is a row of pores round the border. The ovicell has been figured by Smitt in a paper apparently overlooked by Hincks when writing his 'Brit. Marine Polyzoa,' but to which he has subsequently referred. In the Elmwood specimens the ovicells show the front zoëcial wall extending over the lower corners of the ovicell, which is but little raised.

Hincks placed this species under *Mucronella*, on account of the small projection below the aperture, which is not constant, and is sometimes entirely wanting. In a subsequent paper he said perhaps it ought to go to *Monoporella*, and when *Lepralia* and its allies have been thoroughly worked up a group may be separated off as *Monoporella*, though it is doubtful whether there will be any reason for removing *cruenta* from *Lepralia* as we now understand it. This is, however, one of the numerous instances which shows that *Mucronella* ought to be dropped.

*Loc.* Greenland, Spitzbergen, East and West (Sm.); Finland, Matotschkin Schaar; St. Lawrence (Hincks); Franz-Josef Land, lat. 79° 55' N., long. 51° 0' E. (Ridley); Hammerfest (Nordgaard). British seas.

Jackson-Harmsworth Exp.: off Elmwood, 18 fathoms.

32. *LEPRALIA HIPPOPUS*, Smitt. (Pl. 8. fig. 20.)

*Lepralia hippopus*, Smitt, "Krit. Fört." 1867, pp. 20 & 127, pl. xxvi. figs. 99-105; Hincks, Brit. Mar. Polyzoa, p. 309, pl. xxxiii. figs. 8, 9.

This is common on pieces of basalt from off Elmwood, at a depth of 18 fathoms. There are but very few avicularia, and it is often only after careful search that two or three are found on a large colony. The specimens entirely correspond with the description given by Hincks of the specimen from off Northumberland. The operculum does not close the oricell. There is a *Lepralia* allied to this in the Southern hemisphere which has been named by MacGillivray *Schizoporella pulcherrima*. *L. pulcherrima* has a row of large pores round the border, and a semicircular avicularium at each side of the aperture, and the operculum, which is truly Lepralioid, is shorter than that of *L. hippopus*. The latter species is very similar to the *Lepralia incisa*, Busk, from Inaccessible Island (*Challenger*).

*Loc.* Spitzbergen, Greenland, and Finland (*Sm.*); Gulf of St. Lawrence (*Dawson*, and in my coll.). Coast of Northumberland.

Jackson-Harmsworth Exp.: off Elmwood, 18 fathoms.

33. *LEPRALIA PORIFERA* (Smitt). (Pl. 8. figs. 14, 15.)

*Escharella porifera*, forma *typica*, Smitt, Øfvers. Vetensk.-Ak. Förh. 1867, p. 9, pl. xxiv. figs. 30-32.

*Lepralia porifera*, Hincks, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 102, pl. x. figs. 1, 2 (1877).

? *Smittia Landsborovii*, var. *porifera*, Hincks, Brit. Mar. Polyzoa, p. 343, pl. xxxvi. fig. 1 (*non* Ann. Mag. Nat. Hist. ser. 6, vol. i. p. 225, pl. xiv. fig. 2).

*Smittia porifera*, Lorenz, Bry. Jan Mayen, p. 92; Nordgaard, Syst. fort. over de i Norge, hidt. observ. Art. af Mar. Polyz., Bergens Mus. Aarbog, 1894-5, No. ii. p. 26, pl. ii. fig. 1.

The central denticle is wanting, as has been already mentioned by Hincks and others, and in this respect it differs from *Smittia*; also the operculum is fairly thick, and of the *Lepralia*-type, on which account it is placed under *Lepralia*.

*Loc.* Spitzbergen and Greenland (*Sm.*); Norway (*Nordg.*); Davis Straits (*Hincks*), given as Iceland in mistake: Jan Mayen (*Lorenz*). S. Devonshire?

Jackson-Harmsworth Exp.: Lat. 77° 55' N., long. 53° 16' E., 130 fath.

Besides the species already mentioned, *Lepralia megastoma*, B., and *L. vitrea*, Lorenz, are mentioned as Arctic species.

## PORELLA.

The genus *Porella* is very well represented in the Arctic, and therefore some comparisons have been made with *Porella* from various localities, and the opercula and mandibles of some species not occurring in the present collection, as *P. cervicornis*, M.-Edw., *P. laevis*, Flem., *P. rostrata*, Hincks, *P. lorea*, Alder, have been figured. As the result of these examinations, two groups have been made, though it is felt probable that the second may be ultimately separated from *Porella*.

The typical *Porella* may be adnate or erect, and has below or within the aperture an avicularium with a semicircular mandible, and this mandible has well-marked thickenings forming diagonal bars as mentioned by Busk \*.

The operculum is nearly straight on the proximal edge, with the corners cut off, and a muscular ridge on each side a little distance from the border. The ovicells are always or usually imperforate. In the group there is not usually any lyrula (denticle), though in *P. concinna*, Busk, and *P. minuta*, Norm., it can be found. Perhaps with more material the synonyms will be more reduced than I have been able to do in this paper.

The second group has a very wide avicularian chamber, in which there is a pair of large glands. Where there has been suitable material these glands have been found. The operculum has muscular ridges farther from the edge than in the first group, and the mandibles have no marked cross-bars, but a lucida in the middle. The mandibles are usually semicircular, but in *P. acutirostris* they are triangular.

In this group are *P. saccata*, Busk, *P. perpusilla* †, Busk (*elegantula*, d'Orb.); *inflata*, sp. nov.; *P. acutirostris*, Smitt, and apparently *Porella marsupium*, MacG.; perhaps *Lepralia foliacea*, E. & S., and *P. margaritifera*, Quoy & Gaim.

In *P. rostrata*, Hincks, and *P. malleolus*, Hincks, the mandible spreads out at the distal end, and this seems to be the case in some other Australian species, and occurs also in *P. nitidissima*, H.; but as *P. rostrata* has a distinct denticle, perhaps it should be put under *Smittia*. We may here remark that although the well-marked diagonal bars to the mandible are a noticeable character, yet the structure is not confined to *Porella*,

\* Zool. Chall. Exp. pt. xxx. p. 147.

† *P. perpusilla*, Busk, from Newfoundland, has a denticle.

and in some allies the bars are represented by lines, as in one or two species of *Smittia* and *Cellepora*; and in the mandible of *Schizoporella auriculata*, Hass., the markings seem to indicate the same structure.

Besides the species referred to, *P. struma*, Norman, is mentioned from Barents Sea and Finland; and *P. patens*, Smitt, from Spitzbergen.

### 34. PORELLA CONGINNA, Busk. (Pl. 11. figs. 9, 10.)

From lat. 77° 55' N., long. 53° 16' E., there is a small specimen of the typical *concinna* with pores round the edge, and the peristome raised slightly at each side of the aperture. This also occurs off Elmwood, and there is one specimen of the variety fig. 13 of Hincks, Brit. Mar. Polyzoa, also from off Elmwood.

*Loc.* Greenland, Spitzbergen, Finland, Jan Mayen; lat. 79° 55' N., long. 51° 0' E. (*Ridley*); Gulf of St. Lawrence, British Columbia (*H.*); Japan (*Ortmann*). British seas.

Jackson-Harmsworth Exp.: off Elmwood, 18 fathoms; lat. 77° 55' N., long. 53° 16' E., 130 fath.; off Cape Mary Harmsworth, 58-93 fath., and 50 miles off do., 234 fathoms.

### 35. PORELLA COMPRESSA (*Sow.*). (Pl. 11. figs. 3, 4, 5.)

*Millepora compressa*, Sowerby, Brit. Miscell. i. (1806), p. 83, pl. xli.

*Eschara cervicornis*, Busk, Brit. Mus. Cat. p. 92, pl. cix. fig. 7, pl. cxix. fig. 1.

*Eschara cervicornis*, forma *Escharæ*, Smitt, "Krit. Fört." 1867, pp. 23 & 149, pl. xxvi. fig. 138, 139.

*Porella compressa*, Hincks, Brit. Mar. Polyzoa, p. 330, pl. xlv. figs. 4-7, and woodcut; Lorenz, Bryozoen von Jan Mayen, p. 90; Bidentkap, Zool. Jahrb. vol. x. p. 627.

There has been great confusion between this species and the Arctic *Cellepora incrassata*, Sm., and also between these and the Mediterranean *Porella cervicornis*, M.-Ed.; and even Busk, in his List of Polyzoa collected by Captain H. W. Feilden in the North Polar Expedition, gives as *Cellepora cervicornis*, Busk, a form which is probably *C. incrassata*, Sm. Miss Jelly in her Catalogue gives Busk's species under both *C. incrassata* and *P. compressa*, and it seems hopeless to attempt to reduce the synonyms to order. Between *Porella compressa* and *C. surcularis* it is rather a question of names, as the two, although sometimes similar in appearance, are quite distinct in the minute characters. On the other hand, *P. compressa* and *P. cervicornis*



from the Mediterranean are closely allied, but the branches of *P. compressa* are much the broader, and in the British specimens there are several layers of zoëcia in the older parts. In the Arctic specimens the branches are compressed, and about 4 millimetres broad, which is about the same size as those of *P. saccata* and *Escharoides Sarsii*. In *P. cervicornis* there is a bifid denticle on the bar of the avicularium. There are also differences between the mandibles of *Porella cervicornis*, M. Ed., and those of *P. compressa*, which, though not very great, would alone indicate the probability of these being two distinct species.

The Franz-Josef Land specimens have 18 tentacles, and oral glands, but no avicularian glands were seen. There are two distal, and four lateral rosette-plates.

*Loc.* Spitzbergen, Greenland, Jan Mayen (Lorenz), Novaya Zemlya, 30-60 fathoms; Kara Sea (Smitt); Finland; Norway; Bohus Bay; British seas and north coast of France.

Jackson-Harmsworth Exp.: off Cape Mary Harmsworth, 53-93 fathoms.

36. *PORELLA GLACIATA*, sp. nov. (Figs. 2, 3.)

? *Eschara cervicornis*, forma *Lepraliæ*, Smitt, "Krit. Fört." 1867, pp. 23 & 149, pl. xxvi. figs. 136, 137.

A specimen "off the glacier between Cape Flora and Cape Gertrude" is in most respects like *P. inflata*, sp. nov., but the entirely different operculum and mandible show that they are quite distinct (see woodcut, figs. 2 & 3). The operculum is very broad, and has a very muscular ridge, and the mandible corresponds with that of a *Porella* sent to me as *P. propinqua*, Sm. (Pl. 11. fig. 15).

Fig. 1.



Fig. 2.

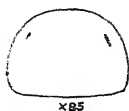


Fig. 3.

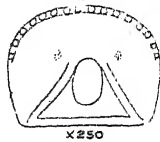


Fig. 1. *Lepralia cruenta*.

Figs. 2, 3. *Porella glacata*.

There is a row of pores by the border with ridges between the pores as in *P. acutirostris*, Sm. (Pl. 10. fig. 10).

The surface of the zoëcia and of the globular ovicells is granular, the peristome is raised at the side, the avicularian chamber is wide and distinct with the mandible within the peristome, but on the top of a more or less tubular projection.

This may be the *Eschara propinqua*, Smitt (pars), but his figures 131, 132, 134 can hardly represent the same species as figs. 126-128.

Jackson-Harmsworth Exp.: off glacier between Cape Flora and Cape Gertrude, about 30 fathoms.

37. *PORELLA PLANA*, *Hincks*. (Pl. 11. figs 11-13.)

*Porella Skenei*, Ell. & Sol., form *plana*, *Hincks*, Ann. Mag. Nat. Hist. ser. 6, vol. i. p. 221, pl. xiv. fig. 6 (1888).

*Porella concinna*, granular var., *Hincks*, Ann. Mag. Nat. Hist. ser. 6, vol. ix. p. 156, pl. viii. fig. 6 (1892).

The zoarium is bilaminar, foliaceous, though in one small specimen from lat. 77° 55' N., long. 53° 20' E., 130 fath., there is only the creeping portion from which the colony arises. *Hincks* does not say whether his granular variety of *P. concinna* is foliaceous or encrusting. The shape of the zoecium and also of the secondary orifice is subject to great variation, and numerous round avicularia are scattered over the surface. In the younger zoecia there is an avicularium at the proximal edge of the aperture, and usually one on each side, more or less raised and turning inwards, with a few avicularia on the surface of the zoecium. In older zoecia these avicularia are within the aperture and there may be more than three; the surface is finely granular with large pores round the border of the zoecium; the ovicells, which are also finely granular, are in some cases almost entirely concealed, in others are raised and globular.

There are about 20 tentacles, avicularian glands, and also oral glands.

I cannot agree in considering this a variety of *P. Skenei*, and think it is entitled to specific distinction, though no doubt closely allied to *P. concinna*, Busk.

*Loc.* Gulf of St. Lawrence, Trinity Bay, 96 fath. (*Hincks*).

Jackson-Harmsworth Exp.: Lat. 77° 55' N., long. 53° 20' E., 130 fath., and also lat. 77° 55' N., long. 53° 16' E., 130 fath.

38. *PORELLA SKENEI*, var. *PROBOSCIDEA*, *Hincks*. (Pl. 11. figs. 17, 18.)

*Porella proboscidea*, *Hincks*, Ann. Mag. Nat. Hist. ser. 6, vol. i. p. 223, pl. xiv. fig. 4; Nordgaard, Bergens Mus. Aarbog, 1894-5, p. 25, pl. i. fig. 4. ? *Eschara verrucosa*, Smitt, "Krit. Fört." 1867, pp. 22 & 142, pl. xxvi. fig. 135.

From off Cape Mary Harmsworth there are some specimens growing adnate upon *Cellepora incrassata* and *Scrupocellaria*

*scabra*; but only in one or two specimens are the lateral avicularia found, and then only to some of the zoecia. The suboral avicularium is much raised, the rostrum being continued beyond the avicularium; there are a row of pores round the border of the zoecium, and the ovicell is wide and not punctured. There are many points of resemblance to *P. concinna*, Busk.

*Loc.* Gulf of St. Lawrence, Orphan Bay, and off Cape Rozier, 38 fath. (*H.*). If this is Smitt's species then also Spitzbergen, Novaya Zemlya and Kola; Finland and North Cape (*Nordgaard*).

Jackson-Harmsworth Exp.: off Cape Mary Harmsworth, 53-93 fathoms.

39. *PORELLA SKENEI*, *Ell. & Sol.*, var. *TRIDENS*, *Kirchenpauer*. (Pl. 11. figs. 6, 7.)

*Cellepora tridens*, Kirchenpauer. Untersuchungs-fahrt der Pommerania, p. 188, figs. a & b.

? *Eschara Skenei*, var. *tridens*, Busk, Ann. Mag. Nat. Hist. ser. 2, vol. xviii. p. 33, pl. i. fig. 3 (1856).

*Cellepora ramulosa*, Manzoni, "Bry. foss. Ital." Sitzungsber. K. Akad. Wissensch., math.-nat. Cl. vol. lxi. pt. 1, 1870, p. 12, pl. v. fig. 29, pl. vi. fig. 30; Waters (part), Ann. Mag. Nat. Hist. ser. 5, vol. iii. p. 196.

*Palmicellaria Skenei*, var. *tridens*, Hincks, Brit. Mar. Polyzoa, p. 380; Waters, Zool. Chall. Exp. pt. lxxix. p. 36 (vol. xxxi.).

The *Porella Skenei* group does not furnish sharp lines by which the ordinary rather stout *P. Skenei*, E. & S., can be readily distinguished from the less stout form with flattened branches known as *Porella lorea*, Alder, which is somewhat stouter than the present cylindrical form with oral avicularia, usually on well-marked cylindrical processes; the number of these processes in the specimens examined is usually 3, but Kirchenpauer says 4 are frequent. The *Porella elegans*, Alder, is still more delicate, but so far has only been found where a stouter form also occurs.

Smitt united *Porella lorea* (Alder) and *Porella elegans* (Alder) under *Discopora Skenei*; and it is doubtful whether they will permanently be separated, though at present it may be advisable to indicate in which form the growth has taken place, and it must be remembered that the operculum is much wider and shorter in *P. lorea*, Alder, so that perhaps on this account it should be separated. *P. bicornis*, Busk, of the Crag is also closely allied, but it has not been proved to be the same as the erect species.

The operculum of *P. Skenei* is longer in proportion to the width than in most of the typical *Porella* such as *P. laevis*, Flem. The mandibles have the characteristic diagonal bars and a raised line below.

*Loc.* Of this variety, Bukenfjord (*Kirchenpauer*); off Nova Scotia (*Waters*); Naples and Capri (*Waters*); Norway. [Spitzbergen, *Nordg.*]

Jackson-Harmsworth Exp.: Lat. 77° 55' N., long. 53° 20' E., 130 fathoms.

Other varieties are stated to have been found in Norway, Finland, Spitzbergen, Kara Sea, Jan Mayen, Greenland, Shetland, &c., and the coast of France.

40. *PORELLA SACCATA*, Busk. (Pl. 10. figs. 8-12, 14-17.)

*Eschara saccata*, Busk, Ann. Mag. Nat. Hist. ser. 2, vol. xviii. p. 33, pl. i. fig. 5.

*Eschara elegantula*, Smitt, "Krit. Fört." 1867, pp. 24 & 154, pl. xxvi. figs. 140-146; Busk, Zool. 'Challenger' Exp., pt. xxx. p. 141, pl. xx. fig. 6; id. Journ. Linn. Soc., Zool. vol. xv. p. 235.

*Porella elegantula*, Levinsen, Bry. fra Kara-Havet, p. 318 (14); Hincks, Ann. Mag. Nat. Hist. ser. 6, vol. i. p. 222, pl. xv. fig. 5; Bidentkap, Zool. Jahrb. vol. x. p. 627.

*Lepralia elegantula*, Lorenz, Bry. von Jan Mayen, p. 89.

For other synonyms see Miss Jelly's Catalogue.

As it seemed doubtful whether the *Eschara elegantula* of Smitt is the same as the *E. elegantula*\* of d'Orbigny, I stayed in Paris, *en route*, in order to examine the specimen described by d'Orbigny, and that I found is what Busk has since described as *Porella perpusilla*.

It should not be overlooked that the specimen with which Smitt made the comparison was, according to Smitt, marked "*Eschara fascialis*." The specimen from which no doubt d'Orbigny's description was taken is not so marked, so that I do not gather what Smitt examined.

D'Orbigny's original specimen No. 13622 of *Eschara elegantula* from Newfoundland, now in the Musée d'Histoire Naturelle in Paris, is composed of cylindrical branches between one and two millimetres in diameter, with the ordinary avicularia much smaller than in the more common *P. saccata*, but the mandibles of both are similar (compare Pl. 10. figs. 11, 12, 13). In the Paris specimen already alluded to the avicularia are sometimes

\* *Eschara elegantula*, d'Orbigny, Pal. Franç. vol. v. p. 102.

gigantically developed, to which d'Orbigny referred when he wrote "pourvus latéralement de cellules plus grandes formant une partie dentée" (Pl. 10. fig. 19). These gigantic avicularia have not been found in *P. saccata*, B. A sketch of the colony (which I should call a memorandum sketch) to give an idea of the growth is reproduced, but this is not an exact drawing (Pl. 11. fig. 1). D'Orbigny's species either must stand for the cylindrical form, or, not having been recognized, becomes *P. perpusilla*, B., being of course closely allied to *P. saccata*, B.; but there seems sufficient reason for separation. Unfortunately Busk's figures and descriptions of *P. saccata* are far from satisfactory.

Another specimen marked in pencil "13622 Terre Neuve, *Eschara elegantula*" is probably a mistake, and was not so marked by d'Orbigny.

Fischer unites *E. pavonina*, d'Orb., with *Porella elegantula*, d'Orb., but the specimen 13621 from the Ile de Ré is flabelliform (fig. 2, Pl. 11), with avicularian chambers smaller than those in *P. saccata*, and also has the ovicells imperforate and not much raised.

The Arctic specimens of *P. saccata* which I have examined start from a broad base, and the colonies grow to 3-4 inches in height, with compressed branches about 4 millimetres broad; the branches often gradually curve round, so that they are not all in one plane as described by Busk in his 'Challenger' specimens. On the front of the zoecium, near the proximal end, there are two pores which open into the avicularian chamber (fig. 14, Pl. 10). These are shown by Smitt in his figure 143, which seems to be from a worn specimen. The pores are not always seen when the zoecium is covered by the exterior membrane, but in specimens boiled in caustic potash and in sections these pores can be made out, and they can also be distinguished in d'Orbigny's specimen of *P. elegantula* from Newfoundland, and readily in the 'Challenger' specimens.

Sections show that there are very large oral glands which are placed nearer the basal (neural) wall than are the tentacles, that is they are underneath the tentacles, which is not a usual position for the glands. The cells forming these glands often have large vacuoles, and the contents of the glands are the same homogeneous unstainable material which we have seen in other glands. No avicularian glands were found. Specimens from near Wilczek Land, collected 16th or 17th July, 1897, have well-developed ovaria and testes.

There are 16 to 17 tentacles, and one lateral and two distal rosette-plates.

*Loc.* Spitzbergen, 30–65 fath.; Greenland; Finland, 30–60 fath.; Kara Sea, 46–75 fath. (*Levinson*); Jan Mayen, 140–180 metres (*Lorenz*); Barents Sea (*H.*); Novaya Zemlya; Labrador; Baffin's Bay; off Nova Scotia, 51 fath. (*Challenger*); Murchison Sound, 45 fath. (*Hennig*).

Jackson-Harmsworth Exp.: off glacier between Cape Gertrude and Cape Flora, about 30 fath.; off Northumberland Island; "off L. S. H.," about 15 fath.; near Wilczek Land, 127 fath.

41. *PORELLA ACUTIROSTRIS*, *Smitt*. (Pl. 10. figs. 1–5.)

*Porella acutirostris*, *Smitt*, "Krit. Fört." 1867, p. 21, pl. xxvi. figs. 106–108; *Lorenz*, *Bryozoen von Jan Mayen*, p. 90 (8); *Hincks*, *Ann. Mag. Nat. Hist.* ser. 6, vol. iii. p. 429, pl. xxi. fig. 5.

*Porella major*, *Hincks*, *Ann. Mag. Nat. Hist.* ser. 5, vol. xiii. p. 51 (25), pl. iv. fig. 5.

Specimens from off Northumberland Island, about 15 fath., have the surface of the zoecium and of the ovicell granulated. The shell when mounted in balsam is very transparent, so that the contents of the avicularian chamber can be readily examined, and the pair of large avicularian glands are seen to extend across a great part of the chamber. This tumid avicularian chamber spreads quite across the zoecium and contracts at each side. These glands are similar to those of *Lepralia margaritifera*, *Quoy & Gaim.*, and *Lepralia foliacea*, *E. & S.*, though somewhat larger, and, judging from the shape of the avicularian chamber of *P. inflata*, sp. nov., it also doubtless has large glands. The wall of the gland is formed of a layer of nucleated cells, and the contents of the glands are a yellowish homogeneous substance which does not stain. There are 17 tentacles.

*Loc.* Spitzbergen, 16–40 fath.; Greenland (*Sm.*); Jan Mayen, 20–180 metres; St. Lawrence (*H.*); Cumsheva and Houston-Stewart Channel (Queen Charlotte Islands) (*H.*).

Jackson-Harmsworth Exp.: off Northumberland Island, about 15 fath.

42. *PORELLA INFLATA*, nom. nov. (Pl. 10. figs. 6, 7.)

*Porella laevis*, *Smitt*, pars (non *Flem.*), "Krit. Fört." 1867, p. 21, pl. xxvi. figs. 112–114, and probably 109–119.

In the *Hemeschara* stage from "between Cape Flora and

Cape Gertrude, 30 fathoms," the zoëcia are hexagonal, granulated, having a raised avicularian chamber extending across the zoëcium, with the avicularian opening somewhat raised and just within the oral aperture, but directed upwards and with a small round mandible. The mandible has a central lucida, but has no diagonal bars as in *P. lævis* from Shetland (Pl. 11. fig. 14). Through the semitransparent walls of the avicularian chamber no avicularian glands can be seen, though no doubt, from the shape of the chamber, they occur at some seasons at any rate. The peristome is raised at each side, but is not continuous round the edge of the aperture. The ovicell is globular, narrow, much raised, with the granulations more distinct than over the surface of the zoëcium.

The *P. lævis*, var. *subcompressa*, Busk, may be related to *P. lævis* of Fleming, but differs considerably from the Arctic *P. inflata*. The var. *subcompressa* is given by Kirkpatrick as found off Port Phillip, Australia. Although Smitt placed some adnate specimens from various localities under *P. lævis*, forma *lepralia*, he does not seem in any way to have shown that there was any identity with the erect *P. lævis*, Flem., and further seems to have placed two or three species together as *P. lævis*.

*Loc.* Spitzbergen, 20-30 fath. (*Sm.*); Bohus Sea; Norway; Finland.

Jackson-Harmsworth Exp.: between Cape Flora and Cape Gertrude, 30 fath.

43. PORELLA? OBESA, sp. nov. (Pl. 12. figs. 22-24.)

A specimen from off Elmwood, encrusting a *Balanus*-shell, has a thick shell with finely granulated surface, and pores round the border which can only be seen in the younger zoëcia. The avicularian chamber is wide, extending to the edge of the zoëcium, but the outline can only be seen in the younger zoëcia; in the same way the ovicell is raised in the younger zoëcia, but in the older ones is quite depressed; and the operculum does not close the aperture of the ovicell. There are pore-chambers, 6-8 in all. The lower edge of the operculum makes a large curve, indicating that there is a broad sinus to the oral aperture, and there are two muscular dots a short distance from the border of the operculum. The characters of the operculum would suggest that the species should be placed under *Schizoporella*, and near what we may call the *S. biaperta* group. The small avicularian

mandible also has not the cross thickenings characteristic of typical *Porella*, but has a central lucida. There is, however, a small group, left for the present doubtfully under *Porella*, though probably a genus will have to be made for it when it is fully worked up. In this group the avicularian chamber is very broad, and in the species which have been studied contains a pair of large avicularian glands. The opercula, instead of the long muscular ridges of typical *Porella*, has muscular dots which may be a little elongate. The mandibles have no cross bars, but have a central lucida. The group at present consists of *P. saccata*, Busk, *P. acutirostris*, Sm., *P. obesa*, sp. nov., *P. inflata*, sp. nov., and probably *P. (Lepralia) margaritifera*, Quoy & G., and *P. marsupium*, MacG.

44. *ESCHAROIDES SARSII*, Smitt. (Pl. 11. figs. 21-23.)

*Escharoides Sarsii*, Smitt, "Krit. Fört." 1867, pp. 24 & 158, pl. xxvi. figs. 147-154.

I do not think that either *Eschara grandipora* of Blainville or *E. lobata* of Lamarck are synonyms.

Smitt gives the avicularium as triangular, and on this ground it is separated from *E. rosacea*, Busk; but in the specimens now examined, and also in a specimen from the Gulf of St. Lawrence, the mandible is rounded at the distal end, though Hincks speaks of the pointed mandible. Looking down on the avicularium, it may appear triangular, but none of the mandibles that I have been able to examine, either in my own collection or in the British Museum, including the one described by Ridley from Franz-Josef Land and the 'Challenger' specimens, have I seen a triangular mandible or one that could be called "acute." With these very small avicularia a mistake is easily made unless the mandible is prepared out. The mandibles are not symmetrical and the amount of irregularity varies, as also the size; but in the Chilostomata the avicularia generally are subject to considerable variation in size, whereas as a rule the opercula are in a species all of one size, often in a specimen all the opercula seem to correspond in size most exactly.

The operculum is thin, transparent, membranous, with a thickened bar across.

The ovicell is but little raised, and sometimes there is an elongate area in front. The small avicularium occurs within the peristomial aperture.

Some branching pieces of *E. Sarsii*, Sm., and *Porella compressa*.



Sow., from the same locality are undistinguishable from the shape of the colony; and when dealing with the earlier descriptions, where the form of growth was considered the most important character, it is impossible to judge which species is referred to. It is also said to occur encrusting shells and stones.

There are 16 tentacles. There are small oral glands which seem to be attached to the sheath. The contents of the pore-tubes at a slight distance from the external surface of the zoecium are large elongate cells, with a central nucleus, but near the surface the cells are smaller.

A figure of the operculum (fig. 25) and mandible (fig. 24) of *Escharoides rosacea*, Busk, from Loch Tyne is given for comparison. The operculum of *rosacea* has a thin muscular ridge at each side and the lower edge of the operculum is nearly straight. The mandible is semicircular, and has a small median lucida and a thinner part at each side, both opercula and mandible being of the *Porrella* type. The mandible in *rosacea* is however lateral instead of being median.

I have referred at some length under *Oribilina punctata*, Hass. (p. 62), to the three species of common Arctic Bryozoa said to have been found in the Antarctic by Hooker, in the 'Erebus' and 'Terror,' and have suggested the probability of an error in labelling having occurred.

The mandibles of the 'Erebus' and 'Terror' specimen are characteristic of *E. Sarsii*, and fall within the range of the Arctic specimens examined.

*Loc.* Spitzbergen, 20-60 fath.; Greenland; Finland (*Sm.*); Kara Sea, 49-65 fath. (*Levinson*); Jan Mayen, 160-180 metres (encrusting, no avicularia); Franklin Pierce Bay, Smith's Sound, 13 fath. (*Busk*); Gulf of St. Lawrence (*Hincks*); Northumberland Island (*Hennig*); off Franz-Josef Land, lat. 79° 55' N., long. 51° 0' E. (*Ridley*). According to Hooker and Busk, lat. 74° 0' S., long. 172° 0' E., 330 fath.

Jackson-Harmsworth Exp.: off glacier between Cape Flora and Cape Gertrude, about 30 fath.; off Cape Mary Harmsworth, 53-93 fath.

#### 45. PORINA TUBULOSA, Norman.

*Lepralia tubulosa*, Norman, Rep. Brit. Assoc. 1868, p. 308.

*Anarthropora monodon*, forma *minuscula*, Smitt, "Krit. Fört." 1867, pp. 7 & 65, pl. xxiv. figs. 20 & 22.

For other synonyms see Miss Jelly's Catalogue.

The suboral pore enters the peristome above the operculum.

The oral aperture has a small tooth on each side, forming a Schizoporellidan aperture.

*Loc.* Spitzbergen, 30-50 fath.; Barents Sea (*D'Urban*); Jan Mayen, 15-180 metres; Davis Straits, 100 fath. (*H.*); Gulf of St. Lawrence (*H.*); Shetland and Wick.

Jackson-Harmsworth Exp.: off Elmwood  $\frac{2}{3}$  mile, 18 fath.; Günther Sound, 10 fath.; nr. Wilczek Land, 127 fath.

46. *MICROPORELLA SPATULIFERA* (*Smitt*). (Pl. 12. fig. 6.)

*Lepralia spatulifera*, Smitt, "Krit. Fört." 1867, pp. 20 & 124, pl. xxvi. figs. 94-98; Lorenz, "Oest. Polarstation Jan Mayen," p. 89.

There is one specimen from near Wilczek Land, and I have one in my collection from the Gulf of St. Lawrence, sent to me by Canon Norman, and in both cases there is in many zoecia below the club-shaped process a tubular pore or perhaps avicularium, and it would seem that the species should be removed from *Lepralia* to *Microporella*. The shape of the aperture is that of *Microporella*, and not of *Porina*. The zoecia and the ovicells are punctate, with one pair of stout spines and one pair of thinner ones above the oral aperture, and one or two small oval avicularia at the side of the aperture. The operculum is thin and does not show the subtriangular shape of the aperture, the distal end is round and the sides are nearly straight. The ovicell is not much raised, in fact sometimes not at all. The wide club-shaped process is articulated.

The specimen was so loaded with grains of sand, that it was hopeless to attempt to cut sections.

Hincks in his papers on the St. Lawrence Bryozoa does not mention this species.

*Loc.* Spitzbergen (*Sm.*); Finland (*Sm.*); Jan Mayen, 100-180 metres (*Lorenz*); Gulf of St. Lawrence (*A. W. W. coll.*).

Jackson-Harmsworth Exped.: nr. Wilczek Land, 127 fathoms, on shell.

47. ? *SMITTIA JACKSONII*, nom. nov. (Pl. 12. fig. 18.)

*Mucronella coccinea*, Bidentkap, Bry. von Ost-Spitzbergen, Zool. Jahrb. vol. x. p. 624, pl. xxv. figs. 5, 6.

Wherever it may ultimately be placed, it seems advisable that this Arctic form should be recorded either as a species or variety. In some points it differs decidedly from the British and Mediterranean *Mucronella coccinea*, Abild.; but it is waste of time trying to decide what Abildgaard meant, in consequence of his meagre description and figures.

As pointed out by Bidekap, there are 4 oral spines, whereas in the British and Mediterranean *M. coccinea* there are usually 6, though in a beautiful specimen of the tessellated variety from Etrétat there are only 4. I have been unable to find any lyrula (central denticle); there is a sinus in the much raised secondary aperture, and internal thickenings on both sides of the sinus. There are about 8 pore-chambers to each zoecium, and 20-21 tentacles. The ovicell is smaller than in the Naples *M. coccinea*, but the shape of the zoecia and avicularia is similar, and the surface is coarsely granulated. Growing on *Diastopora intricaria* there are the primary and the second zoecium of a *Smittia*, which no doubt is the *S. Jacksonii*. The primary has 13 spines, and the second zoecium with the mucro much raised has 8 spines. The Naples and British *coccinea* has 12-13 spines to the primary zoecium. In the sections cut no glands are recognized.

This in many respects is similar to *Smittia præstans*, Hincks, from Australia, especially in the shape of the peristomial sinus (see my figure, Ann. Mag. Nat. Hist. ser. 6, vol. iv. pl. iii. fig. 7).

*Loc.* Spitzbergen.

Jackson-Harmsworth Exp.: Lat. 77° 55' N., long. 55° 25' E., 115 fath.; lat. 77° 55' N., long. 53° 20' E., 130 fath.

48. *SMITTIA TRISPINOSA*, var. *LAMELLOSA* (Smitt). (Pl. 12. figs. 19-21.)

*Escharella Jacotini*, forma *lamellosa*, Smitt, "Krit. Fört." 1867, pp. 11 & 86, pl. xxiv. figs. 53-57.

*Lepralia Jeffreysii*, Norman, Proc. Roy. Soc. vol. clxxiii. p. 208.

*Lepralia trispinosa*, Johnst., var., Hincks, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 100, pl. xi. fig. 1.

*Smittia trispinosa*, var. *arborea*, Levinsen, Bry. fra Kara-Havet, p. 320 (16), pl. xxvii. figs. 7, 8.

This form should at present be kept distinct, whether we call it *S. lamellosa*, or only a variety. In the Arctic region it seems usually to form erect tubular zoaria. The zoecia are nearly flat and the secondary aperture is not raised, the aperture having a quadrate appearance. The avicularia are triangular, and are directed upwards, usually by the side of the aperture. The ovicells have sometimes a few large perforations as in *S. trispinosa*. There are 17 tentacles and about 14 lateral rosette-plates. There are oral glands; and in the section cut it looks as though there were two pairs, one close up to the diaphragm and one connected with the tentacular sheath lower down.

*Loc.* Spitzbergen (Smitt); Greenland, 100 fath. (Norman &

*Hennig*); Kara Sea (*Levinson*); Davis Straits, 100 fath. (*Hincks*); Dogger Bank (*Hincks*); Reykjavik Harbour, 15-20 fath. (*Wallich*).

Jackson-Harmsworth Exp.: Lat. 77° 55' N., long. 53° 16' E., 130 fath.

Lorenz mentions *S. trispinosa*, Johnst., from Jan Mayen, 160-180 metres.

49. *SMITTIA PEACHII*, *Johnston*.

*Discopora coccinea*, forma *Peachii*, Smitt, "Krit. Förtl." pp. 26 & 170, pl. xxvii. fig. 164; & fig. 167 (as *ventricosa*).

From off Elmwood there are specimens of what may be called very typical *S. Peachii*, Johnst. There are six spines, the surface is granular, and the mucro is distinct. The determination, or rather separation, of *S. Peachii*, Johnst., *S. ventricosa*, Hass., and *S. variolosa*, Johnst., is always a great difficulty, although I have typical specimens of all three. Hincks says that Lorenz has united *S. Peachii* and *S. ventricosa*. This does not seem to have been done by Lorenz, though it has been indicated by others. The genus *Mucronella* is based upon the presence of a mucro; but various authors place *Discopora emucronata*, Sm., with *S. Peachii*, showing the artificiality of the distinction based upon the presence of a mucro.

*Loc.* Various Arctic localities; Kola, Jan Mayen, Gulf of St. Lawrence (*Dawson*). Abundant on the British, French, Danish, and Scandinavian coasts, and is given by Pergens from the Mediterranean. Specimens in my collection from Capri are the var. *octodentata*, Hincks.

Jackson-Harmsworth Exp.: off Elmwood, on basalt and on *Balanus*, 18 fath.

50. *SMITTIA VENTRICOSA* (*Hass.*), var. (Pl. 12. fig. 17.)

*Mucronella ventricosa*, Hincks, Brit. Mar. Polyzoa, p. 363, pl. 1. figs. 6-8.

From off the glacier between Cape Flora and Cape Gertrude there is a *Smittia* which I think must be considered as a variety of *S. ventricosa*, Hass. It is growing on *Hornera*, and the shape of the large, finely granulated zoöcia is variable, often being elongate. The border at the upper part of the aperture is raised, sometimes forming a kind of cap, and near the distal border there are four spines; whereas in *S. Peachii* there are usually six and in *S. ventricosa* four or six, but in both cases the spines are usually lower down. The mucro is not very wide. There are 18 tentacles. I must however confess to never feeling sure in

the determination of *S. Peachii* and *S. ventricosa*, and do not know of any characters by which they can be satisfactorily distinguished.

An examination of the specimen from Franz-Josef Land which Ridley called *Mucronella ventricosa* var. *connectens*, shows the pore-chambers distinctly, and these Ridley termed fenestræ, but they do not furnish any ground for separation as a variety.

The *S. ventricosa* has been found from various Arctic localities, and is common from the British and French coasts, and Manzoni records it from the Mediterranean.

51. *SMITTIA LANDSBOROVII*, *Johnst.*, var. (Pl. 12. fig. 7.)

There is a small encrusting specimen from off Elmwood, 18 fathoms, which seems to be a variety of *S. Landsborovii*. Above the distal border of the oral aperture there is a projecting hood to most zoëcia, and in the ovicelligerous zoëcia this is attached to and extends below the ovicell. The surface of the zoëcium is punctured with large pores.

There has been much confusion concerning *S. Landsborovii*, especially in the Arctic regions, as no doubt several distinct species were alluded to by Smitt under his *Escharella Landsborovii*, and in Busk's British Museum catalogue a mistake was made between *S. reticulata*, MacG., and *S. Landsborovii*.

The type occurs off the British seas, in the Mediterranean, Australis, New Zealand; and Ortmann gives it as from Japan.

*Smittia reticulata*, MacG., *S. reticulo-punctata*, Hincks, *S. trispinosa*, Johnst., *S. rigida*, Lorenz, *S. abyssicola*, Norm., have been mentioned from Arctic localities.

52. ? *PHYLACTELLA LABIATA* (*Smitt*). (Pl. 12. figs. 3 & 4.)

*Discopora coccinea*, forma *labiata*, Smitt, "Krit. Fört." 1867, pp. 27 & 175, pl. xxvii. fig. 176.

*Discopora labiata*, Smitt, *op. cit.* 1878, p. 23.

*Mucronella labiata*, Levensen, Bry. Kara-Havet, p. 323; Bidentkap, Bry. von Ost-Spitzbergen, p. 610.

*Phylactella grandis*, Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. vi. p. 280, pl. xv. figs. 4, 5.

Although probably *Phylactella*, which is so largely based upon peristomial characters, will not be found to be a satisfactory genus as now understood, it has seemed better to leave *P. labiata* here rather than place it under *Smittia*.

The peristome in front is much raised and entire, but behind it is not raised, and there there are four long spines. There is a

row of small pores round the zoëcium, and the surface of the zoëcia and ovicells is finely granulated. The larvæ are large and are more fully developed within the ovicell than is usual; in fact, I have not come upon larvæ as largely developed in any other species, the corona and cilia being very distinct. A sketch (Pl. 12. fig. 5) of a free swimming larva of *Schizoporella unicornis*, Johust., is given for comparison of the size.

There are 21 tentacles; while in a Mediterranean *Phylactella*, which is probably a variety of *collaris*, there are 15 tentacles. In the aperture there is a wide lyrula.

*Loc.* Spitzbergen (*Sm.*); Kara Sea (*Sm.* & *Lev.*), 40–125 fath.; Barents Sea, 160 fath. (*H.*); Finland (*Sm.*).

Jackson-Harmsworth Exp.: off glacier between Cape Flora and Cape Gertrude, about 30 fath.; lat. 77° 55' N., long. 55° 25' E., 115 fath.; lat. 77° 55' N., long. 55° 20' E., and 55° 16' E., 130 fath.

#### RHAMPHOSTOMELLA.

Has a very narrow lyrula, and the fact of its presence indicates the relationship with *Smittia*, and probably it must be placed in the family *Smittiidae*. The operculum is thin and delicate, as in *Smittia*, but there is a raised circular ridge reminding us somewhat of the operculum of *Membranipora hians*, Hincks. The mandibles in some characters approach to those of some *Celleporæ*, as *C. pertusa*, Smitt.

53. RHAMPHOSTOMELLA COSTATA, Lorenz. (Pl. 11. figs. 26, 27; Pl. 12. figs. 1, 2.)

*Cellepora scabra*, Smitt, "Krit. Fört." 1867, pp. 30 & 181, pl. xxviii. figs. 186 & 188.

*Rhamphostomella costata*, Lorenz, Bry. von Jan Mayen, p. 94, pl. vii. fig. 11 (in error 12 in text); Hincks, Ann. Mag. Nat. Hist. ser. 6, vol. iii. p. 426, pl. xxi. figs. 6, 7, 8.

In the Franz-Josef Land specimens, there is a small lyrula, which is slightly bifid, and the suboral rostrum sometimes spreads out at the top as described by Hincks. The gigantic avicularia described by Hincks are very abundant, but the rostral avicularia are usually smaller than in my specimen from the Gulf of St. Lawrence, while the gigantic avicularia are more recumbent. There are no oral spines in the specimens examined. There are 18 tentacles; and the oral glands are well-developed, consisting of two parts: the first, the pendulous part arising from close to the diaphragm (figs. 1, 2), shows no distinct structure, though there

are indistinct traces of a lobular structure and of large cells; to the base of this is attached the second or globular part, in which there are distinct nucleated cells. This division into two separate parts is indicated in the oral glands of many species, and is very distinct in a few, as in *Lepralia eliminata*, Waters.

I am very doubtful whether *R. costata* should be separated from *R. scabra*, Smitt, and think Lorenz has made more species than will stand, but I have not the material for a complete study of this Arctic genus.

*Loc.* Gulf of St. Lawrence (*H.*); Jan Mayen (*Lor.*); Finland.

Jackson-Harmsworth Expedition: off Cape Gertrude, 30 fath.; off Cape Mary Harmsworth, 53-93 fath.

54. RHAMPHOSTOMELLA PPLICATA (*Smitt*). (Pl. 11. figs. 28, 29.)

*Cellepora plicata*, Smitt, "Krit. Fört." 1867, pp. 30 & 184, pl. xxviii. figs. 189-191; Hincks, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 106, pl. xi. figs. 3, 4.

*Smittia plicata*, Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. xiii. p. 52.

*Rhamphostomella plicata*, Lorenz, Bry. von Jan Mayen, p. 94; Hincks, Ann. Mag. Nat. Hist. ser. 6, vol. iii. p. 426.

? *Cellepora bilaminata*, Hincks, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 111, pl. xi. figs. 6, 7.

? *Rhamphostomella bilaminata*, Lorenz, Bry. von Jan Mayen, p. 95, pl. vii. fig. 10.

It is difficult to decide upon the range of variation in *Rhamphostomella*, but it seems as if the species *plicata* must stand, and *R. bilaminata* appears like a vigorous growth of the same, though the absence of spines may be a ground for separation as a variety. At first I named a piece from off Cape Mary Harmsworth *R. bilaminata*, but afterwards put it under *R. plicata*. The zoecium of *R. plicata* is usually nearly smooth, the peristome is much raised, forming a triangular peristomial aperture with a spine on each side, and a minute lyrula within the aperture. There are oral glands close to the tentacular sheath, and there are 17 tentacles.

*Loc.* Spitzbergen, Greenland, and Finland (*Sm.*); Jan Mayen (*Lorenz*); Davis Straits (*H.*); Gulf of St. Lawrence (*H.*); Cumshewa, 20 fath. (Queen Charlotte Islands) (*H.*).

Jackson-Harmsworth Exp.: off glacier between Cape Gertrude and Cape Flora, about 30 fath.; near Wilczek Land, 127 fath.; off Cape Mary Harmsworth, 53-93 fath.

## CELLEPORA.

From the genus *Cellepora* of some years ago, say the time of Busk's British Museum Catalogue, some groups have been separated: first the *Rhynchopora*, Hincks; then I have \* shown that others should be removed to *Lagenipora* of Hincks; Lorenz has made the genus *Rhamphostomella* for an Arctic group. Jullien † created the genus *Osthimosia* for species having a fairly wide sinus in the oral aperture; and later in the same year ‡ MacGillivray divided the *Celleporæ* into holostomatous and schizostomous, leaving those with a nearly straight proximal edge in the aperture as *Cellepora*, calling the rest *Schismopora*. The *Cellepora* of MacGillivray is not represented in the Arctic regions, and only by one or two species in the Northern hemisphere, while they are abundant in the Southern. As I have more than once pointed out, it is unfortunate that MacGillivray did not give a generic name to the holostomatous group, leaving the rest as *Cellepora* to be again reduced as fresh generic characters are found. The *Cellepora* of all the older authors does not remain in the genus of MacGillivray, and as the genus *Osthimosia* was earlier than *Schismopora*, we ought perhaps to accept it, and make a genus *Holostomata* for the *Cellepora* of MacGillivray. All the *Celleporæ* with nearly orbicular apertures, or with a distinct sinus in the aperture, have two muscular dots some distance from the border. This is a character which does not occur in the genus *Lepralia*, but is general in *Schizoporella*; though until the genus *Schizoporella* has been thoroughly worked out, the last word cannot be said about the classification of the *Celleporidæ*. A few so-called *Cellepora* have been removed to *Porella*. Hoping to be able before long to revise the family *Celleporidæ*, it has seemed better to leave the three species at present under *Cellepora*, though all may have to be ultimately called *Osthimosia*, Jull.

## 55. CELLEPORA INCRASSATA, Smitt. (Pl. 12. figs. 11-14.)

*Celleporaria incrassata*, Smitt, "Krit. Fört." 1867, pp. 33 & 198, pl. xxviii. figs. 212, 216.

*Cellepora incrassata*, Smitt, *op. cit.* 1878, No. 3, p. 20; *op. cit.* 1878, No. 7, p. 29; Hincks, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 105; Levinsen, Bry. Kara-Havet, p. 324 (20); Nordgaard, "System. fort. over de i Norge, hidtil. observ. art. af Mar. Polyzoa," Bergens Mus. Aarbog,

\* Journ. R. Mier. Soc. 1899, p. 8.

† Mission du Cap Horn, Bryozoaires, p. 64.

‡ Zool. of Victoria, decade xvii. p. 241.



1894-5, No. 2, p. 33; Stuxberg "Faunan på och kring Novaja Semlja," Vega-Exp. vol. v. 1887, p. 179; Bidentkap, Zool. Jahrb. vol. x. p. 629.

*Cellepora cervicornis*, Busk, Ann. Mag. Nat. Hist. ser. 2, vol. xviii. p. 32, pl. i. fig. 1; id. Journ. Linn. Soc., Zool. vol. xv. p. 238; Lorenz, Bry. von Jan Mayen, p. 95, pl. vii. fig. 12.

*Celleporaria surcularis*, Packard, "List of Labrador Marine Animals," Canadian Naturalist, vol. viii. p. 410.

In both the Mediterranean and Arctic region there is a common species of solid cylindrical *Cellepora* composed of several layers, branching dichotomously, the ends of which are frequently tapering. By the naked eye, species from these two localities cannot be distinguished, and in consequence there has been much confusion, but they are by no means identical and the differences must be recorded. The *Cellepora incrassata*, Lamk., is stated by Lamarck to be a Mediterranean species, and this is probably what I have considered to be the *C. coronopus*, S. Woods; and as the minute characters enabling it to be distinguished were first given by Woods and Busk, I consider that this name should stand for the recent Mediterranean form, as Lamarck's description was quite insufficient. Busk, with a meagre description, named the Arctic form *Cellepora cervicornis*, and in his paper in the Journal of this Society, 1881, considers that it is not the same as the Mediterranean *C. incrassata*, as figured by Marsigli. Unfortunately there has been so much confusion between various forms that have been called *Cellepora cervicornis* and *Eschava cervicornis*, that it would only add to it to retain the name, as Busk himself indicated. The Arctic species has been considered to be the *Celleporaria* of Packard, and this probably is the case, though he says two or three lines in thickness, and does not give the characters which we now look for. In *C. coronopus*, W., from the Mediterranean there are large vicarious avicularia with spatulate mandibles and other avicularia with triangular mandibles of varying sizes\*. In *C. incrassata* there are very large vicarious spatulate avicularia, and also very large vicarious semicircular avicularia, besides the small oral avicularia with semicircular mandibles. In *C. incrassata* there is a small avicularium at each side of the oral aperture, whereas in *C. coronopus* there is a small avicularium to one side of the sinus.

The ovicells of *C. incrassata* are imperforate with an area in

\* Waters, "On the Use of the Avicularian Mandibles in the determination of Chilostomatous Bryozoa," Journ. R. Micr. Soc. ser. 2, vol. v. pl. xiv. figs. 29, 30

front, whereas the prominent small ovicells of *C. coronopus* from the Mediterranean have a number of large pores over the surface.

*C. incrassata* has 17 tentacles.

In the Southern hemisphere there are two solid cylindrical *Celleporæ*. The *C. conica*, Busk, which does not differ much from *C. avicularis*, H., has two oral avicularia, the mandibles of which are semicircular, whereas in *C. avicularis* and *C. coronopus* they are triangular. There are spatulate vicarious avicularia, and perforate globular ovicells. The *C. cylindriciformis*, Busk, has perforated ovicells, a large oral avicularium with triangular mandible rather to the side of the aperture, and also vicarious spatulate avicularia.

*Loc.* Spitzbergen, 16-160 fath. (*Sm.*); Greenland (*Sm.*); Novaya Zemlya, 30-80 fath. (*Sm.*); Matotschkin Schaar, 30-50 fath.; Kara Sea (*Levinson*); Kola, 28-100 fath. (*Sm.*); Jan Mayen (*Lorenz*); Finland (*Sm.*); Norway (*Nordgaard*); Labrador, Davis Straits (*H.*); ? Newfoundland (*d'Orb.*).

Jackson-Harmsworth Exp.: off glacier between Cape Gertrude and Cape Flora, about 30 fath.; Wilczek Land, 127 fath.; off Cape Mary Harmsworth, 53-93 fathoms.

56. *CELLEPORA PUMICOSA*, Busk. (Pl. 12. figs. 15, 16.)

*Cellepora pumicosa*, Busk, Brit. Mus. Cat. p. 86, pl. ex. figs. 5, 6; Hincks, Brit. Mar. Polyzoa, p. 398, pl. liv. figs. 1-3; Waters, Ann. Mag. Nat. Hist. ser. 5, vol. iii. p. 198.

As it is extremely doubtful whether *C. pumicosa*, Linn., is referable to this species, it will be best to accept the first reliable description and figure, and call it Busk's species. The genus does not seem to be a genus of Fabricius, as it was previously employed by Linné.

The specimens from Franz-Josef Land have larger zoëcia than those from the Mediterranean and British seas, the avicularium is also larger, as are the opercula and mandibles. The ovicells are widely open, imperforate or with one, two, or three large pores. It seems almost impossible to find any satisfactory characters for separating *C. pumicosa*, B., *C. armata*, H., and *C. ramulosa*, L.; but in what I have considered *C. pumicosa* the proximal border of the operculum is the arc of a circle nearly as large as that of the distal edge, whereas in *C. armata* and *C. ramulosa* the distal edge fits into what may be called a wide sinus. In all, the oral rostrum may be much longer than is shown in any of the figures with which I am acquainted; and in a specimen

sent to me by Joliet, from Roscoff, as *C. ramulosa* there is a long spinous process beyond the mandible.

This seems to be represented in the Southern hemisphere by the *Cellepora Eatonensis* of Busk, since described by Jullien as *Osthimosia eveza*, Jull.

*Loc.* British seas; Mediterranean.

Jackson-Harmsworth Exp.: Lat.  $77^{\circ} 55' N.$ , long.  $55^{\circ} 25' E.$ , 115 fath.; lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 16' E.$ , 130 fath.; 50 miles N.W. Cape Mary Harmsworth, 234 fath.

57. *CELLEPORA VENTRICOSA*, Lorenz. (Pl. 12. fig. 10.)

*Cellepora ventricosa*, Lorenz, Bry. von Jan Mayen, p. 96, pl. vii. fig. 13.

The zoecia of this species are much larger than those of *C. incrassata*, Smitt, and the two species can be distinguished by the naked eye. The operculum is also longer, and the ovicell is narrow and imperforate. There are 21 tentacles. In the Cape Mary Harmsworth specimens I do not find any vicarious avicularia, nor does Lorenz mention any.

*Loc.* Jan Mayen (Lorenz).

Jackson-Harmsworth Exp.: off Cape Mary Harmsworth, 53-93 fathoms.

58. *RETEPORA CELLULOSA* (L.). (Pl. 12. figs. 8, 9.)

*Retepora cellulosa*, Smitt, "Krit. Fört." 1867, pp. 35 & 203, pl. xxviii. figs. 222-225; Waters, Medit. & New Zealand Reteporæ, Linn. Soc. Journ., Zool. vol. xxv. p. 259, pl. vi. figs. 17 & 20, pl. vii. fig. 12; Bideknapp, Bry. von Ost-Spitzbergen, Zool. Jahrb. vol. x. p. 630.

From off Cape Mary Harmsworth there is a piece about 22 inches in diameter spreading out and forming a rather flat expansion. I am unable to find any oral spines, nor did Bideknapp find any in his Spitzbergen specimens, whereas they are readily found in the Mediterranean *R. cellulosa*. Also the operculum does not widen towards the proximal border so much as in the Mediterranean specimens. These differences are interesting, but are not thought to furnish sufficient ground for separation; and it is curious that this species, common in the Arctic and the Mediterranean, is not found off the British coasts.

*Loc.* Spitzbergen, 19-35 fath., Greenland, Kara Sea, Norway, Adriatic, Naples, Capri, Rapallo, Villefranche-sur-Mer.

Jackson-Harmsworth Exp.: off Cape Mary Harmsworth, 53-93 fath.

## 59. RETEPORA ELONGATA, Smitt.

*Retepora cellulosa*, forma *notopachys*, var. *elongata*, Smitt, "Krit. Fört." 1867, pp. 36 & 204, pl. xxviii. figs. 226-232.

*Retepora elongata*, Levinsen, Bry. fra Kara-Havet, p. 323 (19), pl. xxvii. fig. 11; Bidekap, Bry. von Ost-Spitzbergen, Zool. Jahrb. vol. x. p. 629; Waters, Journ. Linn. Soc., Zool. vol. xxv. p. 256, pl. vi. figs. 9, 10; Hennig, Cefv. af K. Vetensk.-Ak. Förh. 1896, p. 361.

*Discopora elongata*, Smitt, Cefv. af K. Vetensk.-Ak. Förh. 1878, pp. 25 & 32.

*Retepora Wallichiana*, Hincks, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 107, pl. xi. figs. 9-13, 1877; id. *op. cit.* ser. 5, pp. 29 & 42; Nordgaard, Mar. Polyzoa, Bergens Museums Aarbog, 1894-5, No. 2, p. 31.

*Retepora tenella*, Ortmann, Die Japanische Bryozoen-fauna, Arch. f. Naturgesch. 1890, p. 34, pl. ii. fig. 21.

There are 15 tentacles, and large oral glands hanging down from the diaphragm a long way into the zoecium. A specimen from off Cape Mary Harmsworth (Aug. 7th) has the ovaria and testes well-developed.

*Retepora Beaniana*, King, has been found off Jan Mayen.

*Loc.* Spitzbergen, 20-80 fath. (*Sm.*); Greenland; Finland, 50 fath.; Kara Sea (*L.*); Kola (*Sm.*); Novaya Zemlya, 30-50 fath. (*Sm.*); Matotschkin Schaar (*Sm.*, *Stuxb.*); Davis Straits (*H.*); Godthaab, 150 fath.; Murchison Sound (*Hennig in litt.*); Queen Charlotte Islands, 15-20 fath. (*H.*); Vancouver Island (*H.*); Inglefeld Gulf, 25 fath. (*Hennig*); Sagami-bai, Japan, 200 fath. (*Ortmann*).

Jackson-Harmsworth Exp.: off Cape Mary Harmsworth, 53-93 fath.





	Page.	Tentacles.	No. 1 Station.	No. 2. Wilezek.	No. 3. Lat. 77° N.	Cape Mary Harnsworth.		Greenland.	Finland.	Spitzbergen.	Kara Sea.	Noraja Semlya and Barents Sea.	Labrador and Gulf of St. Lawrence.	Jan Mayen.	British.	Mediterranean.	
43. <i>Porella</i> ? <i>obesa</i> , sp. nov.	48	16	..	..	..	53-55 fms.	234 fms.	..	..	..	..	..	..	..	..	..	
44. <i>Escharoides Stenslii</i> Sm.	58	16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
45. <i>Porina tubulosa</i> , Norm.	68	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
46. <i>Microporella spatulifera</i> (Sm.)	87	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
47. <i>Smittia Jacksonii</i> , nom. nov.	48	20-21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
48. " <i>trispinosa</i> , var. <i>lunul-</i> <i>losa</i> (Sm.)	88	17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
49. " <i>Peachii</i> , Johnston.	89	18	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
50. " <i>ventricosa</i> (Hass.), var.	89	18	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
51. " <i>Leandaborovii</i> , J., var.	90	21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
52. <i>Phylactella labiata</i> (Sm.)	90	21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
53. <i>Rhamphostomella costata</i> , Lor.	91	18	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
54. " <i>plicata</i> (Sm.)	92	17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
55. <i>Collepura incrassata</i> , Sm.	93	17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
56. " <i>panicosa</i> , Busk.	95	18-20	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
57. " <i>ventricosa</i> , Lorenz.	96	21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
58. <i>Relepora cellulosa</i> (L.)	96	12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
59. " <i>elongata</i> , Sm.	97	15	..	..	..	..	..	..	..	..	..	..	..	..	..	..	

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## EXPLANATION OF THE PLATES.

## PLATE 7.

- Fig. 1. *Brettia frigida*, sp. nov.,  $\times 12$ . Off Cape Mary Harmsworth.  
 2. Do.; natural size.  
 3. Do. Dorsal surface showing the distal rosette-plate, through the transparent wall,  $\times 25$ .  
 4. *Gemellaria loricata* (L.); Günther Sound. This shows the creeping zoecia from which the branches arise.  $\times 12$ .  
 5. *Brettia minima*, sp. nov.;  $\times 12$ . Off Cape Mary Harmsworth.  
 6. Do.; natural size.  
 7. Do. Dorsal surface,  $\times 25$ .  
 Figs. 8, 9. *Scrupocellaria Smittii* (Norman);  $\times 25$ . 50 miles N.W. Cape Mary Harmsworth.  
 Fig. 10. Do. Avicularium with mandible,  $\times 85$ .  
 11. Do. Avicularian opening,  $\times 85$ .  
 12. *Scrupocellaria ternata*, var. *gracilis*, Sm.;  $\times 25$ . Günther Sound. Showing the articulation. In this specimen some zoecia have two outer spines, and sometimes the median zoecium is acuminate. Lateral avicularia rare.  
 13. *Bugula Harmsworthii*, sp. nov.;  $\times 8$ . Off Cape Mary Harmsworth.  
 14. *Scrupocellaria scabra* (van Ben.);  $\times 25$ . Off Cape Mary Harmsworth.  
 15. Do. Scutum,  $\times 50$ .  
 16. Do. Dorsal surface showing a vibraculum at the bifurcation, and one to a lower zoecium.  $\times 25$ .

## PLATE 8.

- Fig. 1. *Bugula Harmsworthii*, sp. nov.;  $\times 25$ . Off Cape Mary Harmsworth.  
 2. *Lepralia sincera* (Sm.). Operculum,  $\times 85$ . Off Cape Mary Harmsworth.  
 3. *Membranipora monostachys*, Busk;  $\times 15$ . Near Wilczek Land.  
 4. *Lepralia borealis*, sp. nov.;  $\times 25$ . Specimen mounted in balsam, showing through the semitransparent shell the position of the avicularian chamber. From lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 16' E.$   
 5. Do. Operculum,  $\times 85$ .  
 6. Do. Mandible,  $\times 250$ .  
 7. *Pseudoflustra palmata* (Sars). Operculum,  $\times 85$ . Lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 16' E.$   
 8. Do. Mandible,  $\times 250$ .  
 9. Do. Transverse section, showing the two distal rosette-plates.  
 10. *Membranipora macilenta*, Jullien;  $\times 25$ . Near Wilczek Land.  
 11. *Schizoporella crustacea* (Sm.). Mandible,  $\times 250$ . Günther Sound.  
 12. Do. Operculum,  $\times 85$ .  
 13. Do.;  $\times 50$ . Showing primary zoecium and the three zoecia growing from it. The development of the zoecium on the left has been arrested. Günther Sound.  
 14. *Lepralia porifera* (Sm.). Mandible,  $\times 250$ . From lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 16' E.$   
 15. Do. Operculum,  $\times 85$ .



Fig. 16. *Hippothoa hyalina*, L. Operculum of male zoecium,  $\times 85$ . From California.

17. Do.; do. Operculum of female zoecium,  $\times 85$ .
18. Do; do. Operculum of ovicelliferous zoecium,  $\times 85$ .
19. *Hippothoa expansa*, Dawson. Operculum,  $\times 85$ . Off Elmwood.
20. *Lepralia hippopus* (Sm.). Operculum,  $\times 85$ . Off Elmwood.
21. *Cribrilina annulata* (Fab.);  $\times 25$ . Off glacier between Cape Flora and Cape Gertrude.
22. *Cribrilina punctata* (Hass.);  $\times 25$ . Lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 16' E.$

#### PLATE 9.

- Fig. 1. *Schizoporella elmwoodiae*, sp. nov.;  $\times 25$ .
2. *Myriozoum coarctum* (Sars);  $\times 25$ . Off Cape Mary Harmsworth, 234 fathoms.
  3. Do. (a) Operculum,  $\times 85$ . (b) Mandible,  $\times 85$ .
  4. *Myriozoum subgracile*, d'Orb.;  $\times 25$ .
  5. Do. (a) Mandible,  $\times 85$ . (b) Mandible,  $\times 250$ . (c) Operculum,  $\times 85$ .
  6. *M. subgracile*, d'Orb. Section of tissue showing the polypides in position, the covering integument (a), over the inner one (b); also the long pore-tubes which in various places have a disk separating the contents on the two sides of the disk. The oral diaphragm is seen as withdrawn.  $\times 25$ .
  7. *M. subgracile*, d'Orb. Section through polypide showing *dm*, the diaphragm; *op*, the operculum, with dotted lines to show the position when partly open; *d*, disks in the pore-tubes.  $\times 85$ .
  8. *M. subgracile*, d'Orb. End of pore-tube showing the covering integument (a), and the inner one (b),  $\times 500$ . Examined with  $\frac{1}{2}$ -immersion.
  9. *M. subgracile*, d'Orb. Covering integument (a).  $\times 85$ .
  10. *Schizoporella Harmsworthii*, sp. nov.;  $\times 25$ . Lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 16' E.$
  11. Do. Tentacular sheath with oral glands attached near the oral aperture, and connected to the lateral walls;  $\times 85$ . (July 13th, 1897.)
  12. Do. Oral glands,  $\times 250$ .
  13. *Schizoporella elmwoodiae*, sp. nov. Operculum,  $\times 85$ .

#### PLATE 10.

- Fig. 1. *Porella acutirostris*, Sm.;  $\times 25$ . From near Northbrook Island ("L.S.H.").
2. Do. Mandible,  $\times 250$ .
  3. Do. Operculum,  $\times 85$ .
  4. Do. Piece mounted in balsam, showing the avicularian glands through the semitransparent shell,  $\times 50$ .
  5. Do. Section of avicularian gland,  $\times 250$ .

Fig. 6. *Porella inflata*, nom. nov.:  $\times 25$ . From between Cape Flora and Cape Gertrude, 30 fath.

7. Do. Mandible,  $\times 250$ .

8. *Porella saccata*, Busk;  $\times 25$ . From near Wilczek Land, 127 fath. Section showing the position of the oral glands (*gl*), which are behind the tentacles so that they are not seen in the zoecia cut through near the frontal surface; *ov*, ovum.  $\times 25$ .

9. Do. Transverse section showing the large oral glands (*gl*), the avicularian sheath (*av*), the tentacles (*t*), in their sheath, oesophagus (*o*), caecum (*c*), testes (*te*).  $\times 50$ .

10. Do. Oral gland,  $\times 250$ . In the upper part the cells are partly absorbed.

11. *Porella saccata*, B. (*elegantula*, B.). Mandible,  $\times 85$ . Off Nova Scotia ('Challenger').

12. Do. Mandible,  $\times 85$ . Near Wilczek Land.

13. *Porella elegantula*, d'Orb. (*perpusilla*, Busk). Mandible,  $\times 85$ . Newfoundland. From d'Orbigny's type-specimen No. 13622, Mus. Nat. Paris.

14. *Porella saccata*, Busk;  $\times 25$ . Specimen boiled in caustic potash, showing the large avicularian chambers, that of the left zoecium has been broken away, also showing the pores at the base of the avicularian chambers. From near Wilczek Land, 127 fathoms.

15. Do. Operculum,  $\times 85$ .

16. Do. Mandible,  $\times 250$ .

17. Do. Diagrammatic section, showing the frontal pore connected through a rosette-plate with the avicularian chamber, which farther down is similarly connected with the zoecium. (*ov.*) ovicell, (*av. ch.*) avicularian chamber, (*z. ch.*) zoecial chamber, (*m.*) mandible, (*op.*) operculum.

18. *Porella elegantula*, d'Orb. Operculum,  $\times 85$ .

19. Do. From the original specimen No. 13622, showing the gigantic avicularia on the left, and pores on the front similar to those of *P. saccata*, Busk.

#### PLATE 11.

Fig. 1. *Porella elegantula*, d'Orb. Specimen from Newfoundland named *Eschara elegantula* by d'Orbigny, No. 13622 in the Musée d'Histoire Naturelle. This is only a reproduction of a rough sketch made as a memorandum of the way in which the specimen grew. Nat. size.

2. The *Eschara pavonina* of d'Orbigny, Ile de Ré (Pal. Fr. vol. v. p. 101. No. 13621, Mus. d'Hist. Nat.).

3. *Porella compressa*, Sowerby. Operculum,  $\times 85$ . British specimen.

4. Do. Mandible,  $\times 250$ . British specimen. Identical with Arctic.

5. Do. Calcareous section showing the position of the pore-tubes.  $\times 25$ . Off Cape Mary Harmsworth.

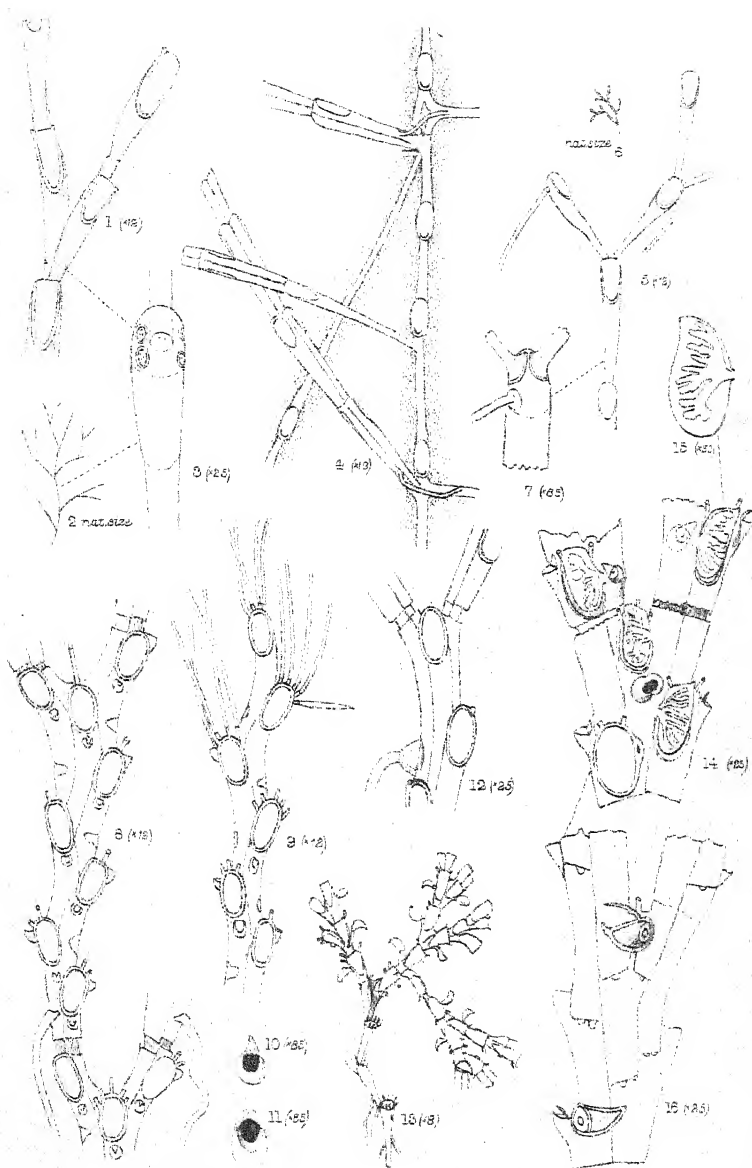
6. *Porella Skenei*, var. *tridens*, Kirch. Operculum,  $\times 85$ . Lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 20' E.$

7. Do. Mandibles,  $\times 250$ .

- Fig. 8. *Porella cervicornis*, Pallas. Mandible,  $\times 250$ . Naples.  
 9. *Porella concinna*, Busk. Mandible,  $\times 250$ . Durham.  
 10. Do. Operculum,  $\times 85$ . Durham.  
 11. *Porella plana*, Hincks. Mandible,  $\times 250$ .  
 12. Do. Operculum,  $\times 85$ .  
 13. Do. Operculum,  $\times 50$ . From lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 16' E.$   
 14. *Porella levis*, Flem. Mandible,  $\times 250$ . Shetland.  
 15. *Porella* from Gulf of St. Lawrence (sent as *P. propinqua*, Sm.). Mandible,  $\times 250$ .  
 16. *Porella rostrata*, Hincks. Mandible,  $\times 250$ . Port Phillip Heads.  
 17. *Porella Skenei*, var. *proboscidea*, Hincks. Mandible,  $\times 250$ . Off Cape Mary Harmsworth.  
 18. Do. Do. Operculum,  $\times 85$ .  
 19. *Porella lorea*, Alder. Mandibles,  $\times 250$ . Shetland.  
 20. Do. Operculum,  $\times 85$ .  
 21. *Escharoides Sarsii*, Sm. Mandible,  $\times 250$ . Off Cape Gertrude and Cape Flora.  
 22. Do. Operculum,  $\times 85$ . Do.  
 23. Do. Mandible,  $\times 250$ . Said to be from the Antarctic, lat.  $74^{\circ} 0' S.$ , long.  $170^{\circ} E.$ ; 330 fathoms.  
 24. *Escharoides rosacea*, Busk. Mandible,  $\times 250$ . Loch Tyne.  
 25. Do. Operculum,  $\times 85$ .  
 26. *Rhamphostomella costata*, Lorenz. Operculum,  $\times 85$ . Off Cape Gertrude and Cape Flora.  
 27. Do. Mandible,  $\times 85$ .  
 28. *Rhamphostomella plicata*, Sm. Operculum,  $\times 85$ .  
 29. Do. Mandible,  $\times 85$ .  
 30. *Rhamphostomella bilaminata*, Hincks. Mandible,  $\times 85$ . Gulf of St. Lawrence.

#### PLATE 12.

- Fig. 1. *Rhamphostomella costata*, Lorenz. Section showing the oral glands terminating near the diaphragm,  $\times 85$ . From off Cape Mary Harmsworth.  
 2. Do. Gland,  $\times 250$ . Examined with  $\frac{1}{2}$ -immersion.  
 Figs. 3 & 4. *Phylactella labiata*, Sm. Larva in ovicell,  $\times 85$ . From lat.  $77^{\circ} 55' N.$ , long.  $53^{\circ} 16' E.$  July 13th.  
 Fig. 5. *Schizoporella unicornis*, Johnst.,  $\times 85$ . Free swimming larva from Trieste, for comparison of the size.  
 6. *Microporella spatulifera* (Sm.),  $\times 85$ .  
 7. *Smittia Landsborovii*, Johnst., var.,  $\times 25$ .  
 8. *Retepora cellulosa* (L.). Operculum,  $\times 85$ . Off Cape Mary Harmsworth.  
 9. Do. Mandible,  $\times 85$ .  
 10. *Cellepora ventricosa*, Lorenz. Operculum,  $\times 85$ .  
 11. *Cellepora incrassata*, Sm. Operculum,  $\times 85$ . From Greenland.  
 12. Do. Vicarious mandible,  $\times 85$ .

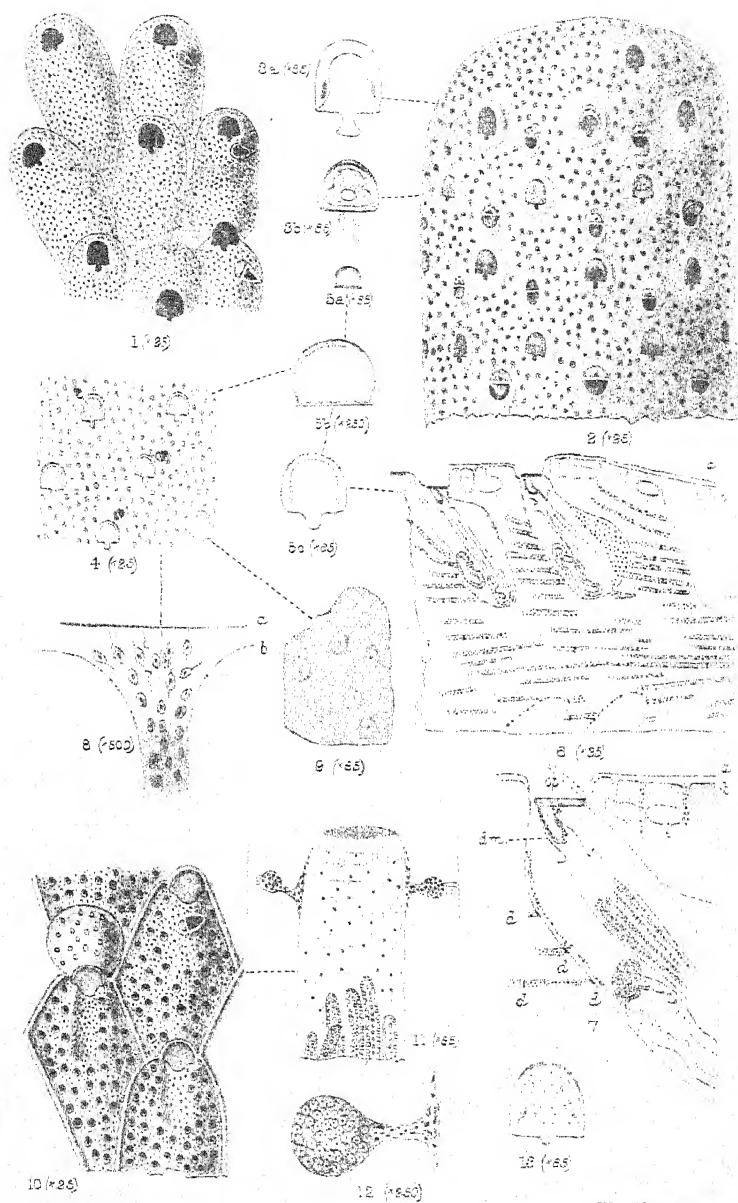


A.W. Waters del.  
A.T. Hollick lith.

West, Newman, inc.

ERYOZOA FROM FRANZ-JOSEF LAND



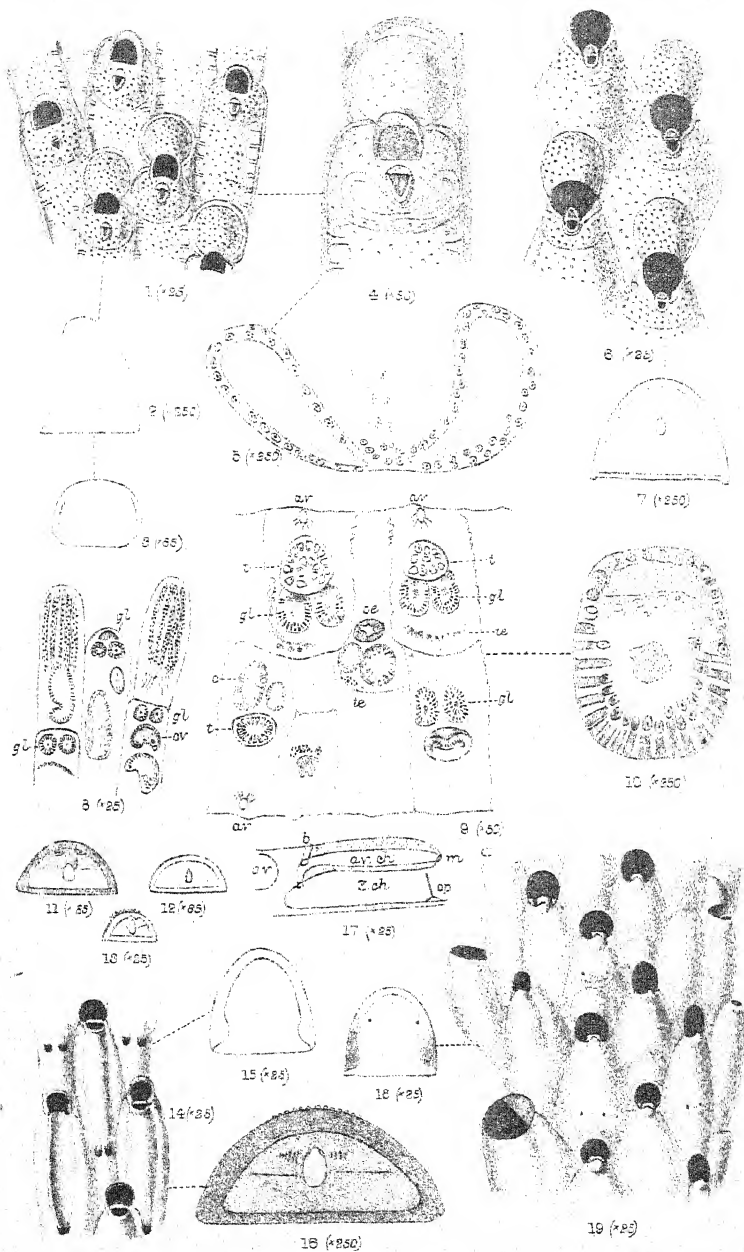


10 (x25)  
A. H. Waters det.  
A. T. Hollick lith.

West. Newman imp.

BRYOZOA FROM FRANZ-JOSEF LAND





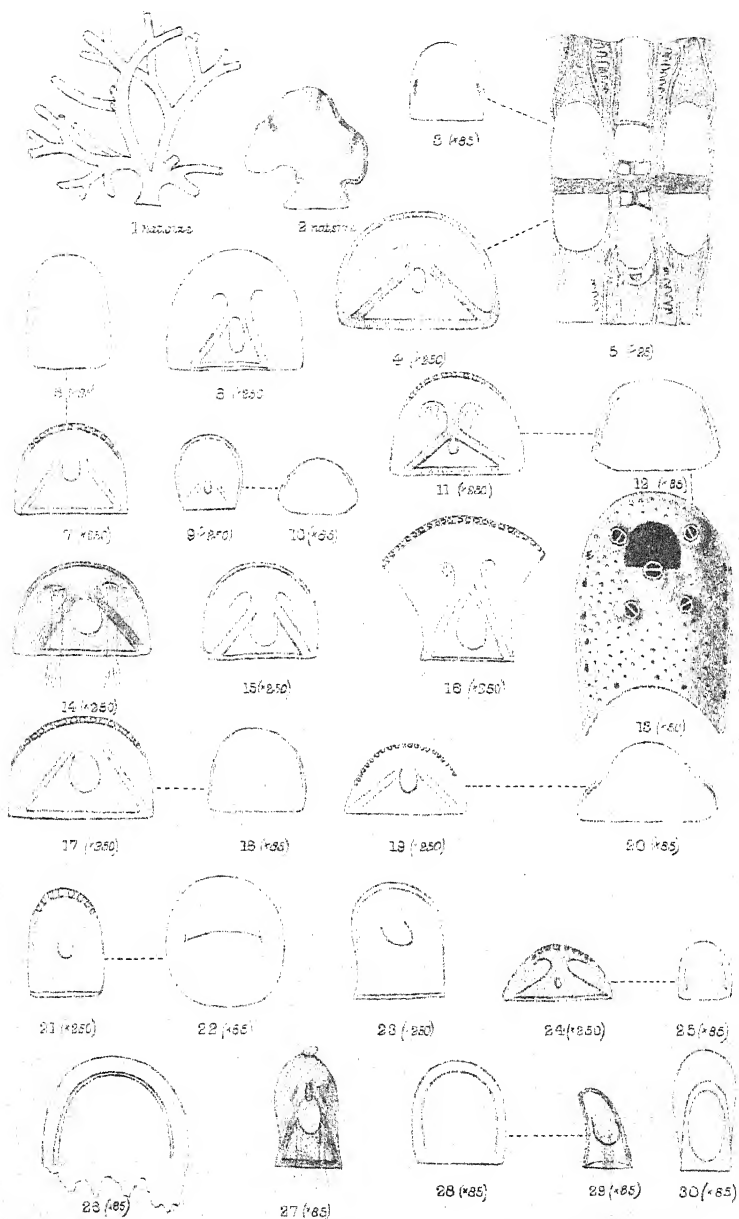
AlW Waters del.  
A.T. Hollick lith

Waters, Newman imp

BRYOZOA FROM FRANZ-JOSEF LAND.





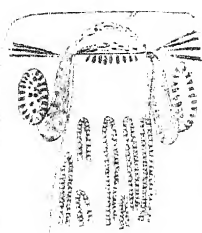


AW. Waters del.  
A.T. Hollick lith.

West, Newman imp.

BRYOZOA FROM FRANZ-JOSEF LAND.

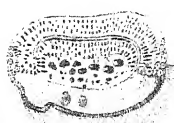




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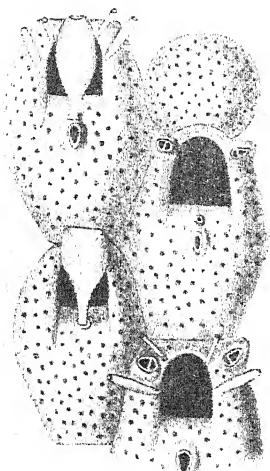
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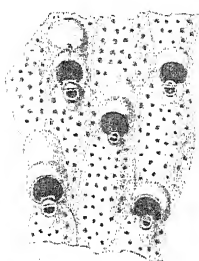
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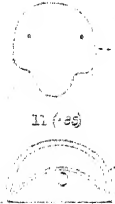


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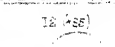


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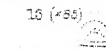


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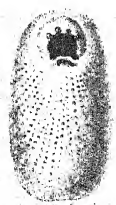


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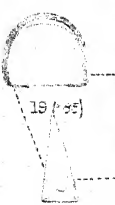
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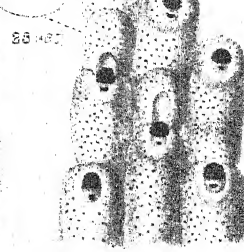
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AW Waters del.  
A.T. Hollick lith.

West. Newman imp.

BRYOZOA FROM FRANZ-JOSEF LAND.



- Fig. 13. *Cellepora incrassata*, Sm. Vicarious mandible,  $\times 85$ . From same specimen as figs. 11 & 12.
14. Do. Lateral oral mandible,  $\times 85$ . From near Wilczek Land.
15. *Cellepora pumicosa*, Busk. Mandible,  $\times 85$ . Lat.  $77^{\circ} 55' N.$ , long.  $55^{\circ} 25' E.$
16. Do. Operculum,  $\times 85$ .
17. *Smittia ventricosa* (Hass.), var.,  $\times 25$ . Off glacier between Cape Flora and Cape Gertrude.
18. *Smittia Jacksonii*, nom. nov. Mandible,  $\times 85$ . Lat.  $77^{\circ} 55' N.$ , long.  $55^{\circ} 25' E.$
- Figs. 19, 20. *Smittia lamellosa* (Sm.). Operculum and mandible.  $\times 85$ .
- Fig. 21. Do. Do.  $\times 25$ .
22. *Porella obesa*, sp. nov. Mandible,  $\times 250$ .
23. Do. Operculum,  $\times 85$ .
24. Do.,  $\times 25$ . Off Elmwood.

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Observations on *Syllis vivipara*, Krohn.  
By EDWIN S. GOODRICH, M.A., F.L.S.

[Read 7th June, 1900.]

(PLATE 13.)

WHILST working last winter at the Zoological Station in Naples, I found in the tank of the large laboratory an interesting small Syllid, which I believe to be the *Syllis vivipara* originally named by Krohn in 1869 (2).

Since Krohn gave but a very brief description of his worm, without figures, merely stating that in general structure it closely resembles Claparède's *Syllis Armandi* (probably *S. prolifera*, Krohn), it is by no means easy to make certain whether we are really dealing with his species. The worm reaches to a length of 2 cm., and appears pale yellow in colour owing to the intestine, which is seen through the transparent and almost colourless body-wall (Pl. 13. fig. 1). The palps are joined together below the prostomium for about half their length (figs. 1 & 2). The dorsal cirri are of considerable length, especially in the anterior region (fig. 1). As Krohn mentions, the terminal joint of the chaetae are provided with a single hook (fig. 6).

Internally, the alimentary canal is of quite normal structure. The pharynx possesses a single tooth, and nine papillae at its anterior end (figs. 1 & 3).

It is with regard to its method of reproduction that this Syllid is of peculiar interest. In all the specimens I examined (about twenty) either ova, or embryos in various stages of development were found in the coelomic cavity of the posterior region. Krohn briefly described this viviparous reproduction, and stated that the embryos grow within the body-cavity of the parent to an advanced stage, when they completely resemble the adult excepting in their smaller size and lesser number of segments. According to this observer, they then escape by the breaking-off of the hinder region of the parent's body.

Ehlers, in his large work on the Polychæta (1), gives an account of Krohn's observations, and suggests that fertilization must take place by way of the nephridia. Since Krohn's note, published more than 30 years ago, no confirmatory evidence has been given of viviparity in any Syllid, excepting for the mere mention of a case (*Syllis incisa*) by Levinsen (3). Malaquin, in fact, in his monograph of these Polychæta (4), throws doubt on the accuracy of the observations recorded by these authors.

The figures herewith given will, I hope, place beyond doubt that we have here a truly viviparous Syllid.

In *Syllis vivipara* the ova are produced only in the posterior third of the body, where they are shed into the coelom in comparatively small numbers. Here they undergo development from before backwards, and as many as eighteen embryos may be found in one parent. The course of development seems to differ in no marked way from that pursued by other Syllids outside the mother. Malaquin's figures of the stages in the ontogeny of *Eusyllis monilicornis* (4) would apply almost equally well to *Syllis vivipara*. As the embryos grow larger they have some difficulty in accommodating themselves within the parental body-cavity. They usually take up a longitudinal position, with their head directed backward, and extend along many segments through the incomplete septa. In fig. 1 (Pl. 13) is shown a worm the young of which must be almost ready to escape. They have fully acquired the parent's form, differing from it only in size. The cilia in the rectum can be seen to work from behind forwards, as in the adult.

We are naturally led to enquire how these embryos are nourished, and how the ova from which they have developed were fertilized.

With regard to the first question, there can be no doubt what-

ever that the yolk stored in the egg is not enough to provide nourishment sufficient for the growth of the embryos to the large size they attain in the body-cavity of the parent. Further food-material the young must derive from the mother during development; and, since there is no special connection of tissues between the two, this food would appear to be taken in either by mere diffusion through the general surface of the body, or by the mouth or anus. In some such way the embryos must obtain nourishment from the coelomic fluid of the mother.

The second question is less easy to answer. In the first place, since all the specimens I found contained ova, it is just possible that we have here a case of parthenogenetic development\*. Should, however, spermatozoa actually at some time penetrate to the coelom and fertilize the ova, it is by no means easy to see how such a process could take place. The surface of the body is covered with a cuticle, and it is not likely that the spermatozoa reach the coelom by entering the alimentary canal and boring their way through its wall. The only other means of access would appear to be the nephridia. Now these organs, so far as I have seen, do not undergo any of those changes in size and structure at maturity, such as are known to take place in many allied forms. The nephridia are delicate tubes, with a very narrow lumen, opening internally by a small nephrostome, and externally by a minute pore. The cilia of the nephrostome and of the canal act in such a way as to force substances down the canal to the exterior. That spermatozoa struggle up this narrow and difficult path is hard to believe.

One possibility remains to be considered, though it must be admitted to be a somewhat improbable one—namely, that it is a case of self-impregnating hermaphroditism. A few viviparous hermaphrodite Polychaetes are known, such as *Nereis diversicolor*, *Salmacina Dysteri*, and *Pomatoceros triqueter*; and it has been suggested by Schröder for the first species (7), and by de Saint-Joseph for the two last (6), that in these worms self-impregnation occurs.

The evidence of hermaphroditism in *Syllis vivipara* is by no means convincing. In sections of the hinder segments, whilst

\* MM. Mesnil and Caullery have already suggested that in one viviparous form of the Cirratulid *Dodecaceria concharum* the development of the ova is parthenogenetic (5).



ova can be seen loose in the body-cavity, the segmental gonads have in places very much the appearance of testes, the cells at the periphery being numerous and small; but I have never found ripe spermatozoa, and the point remains doubtful. It is in the hope of inducing some observer to settle this interesting question, that I publish the foregoing observations.

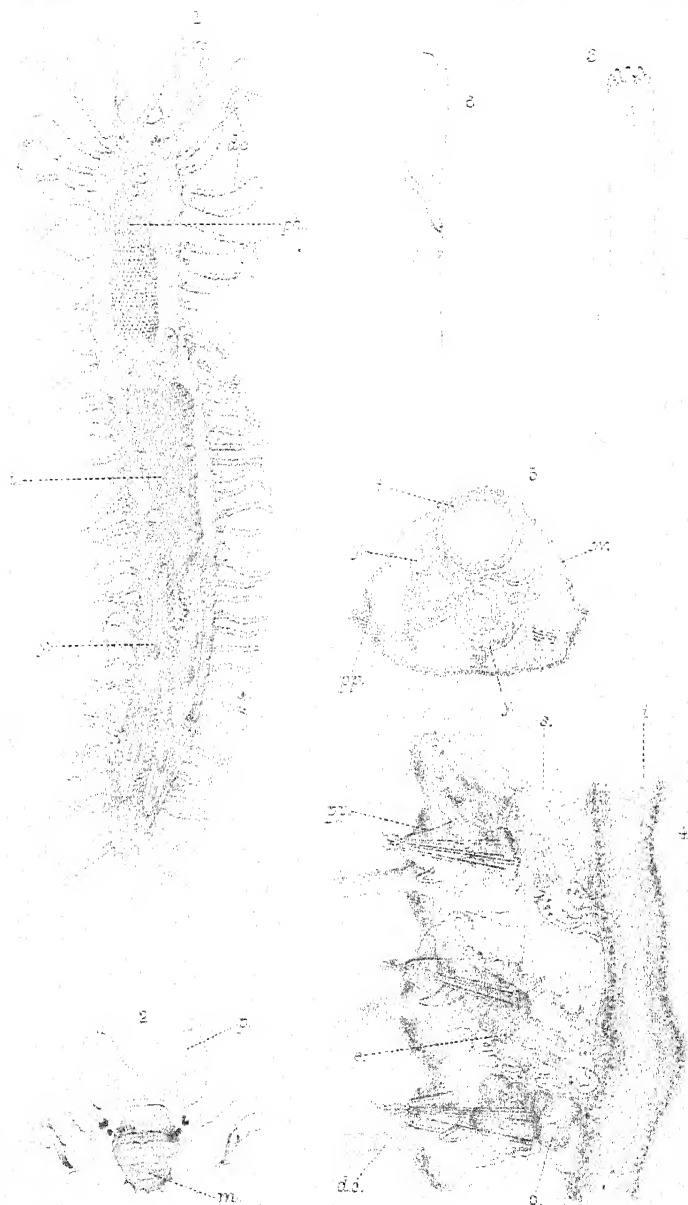
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- (2) KROHN, A.—"Ueber ein lebendiggebärend Syllisart." Arch. für Naturg. vol. xxxv., 1869.
- (3) LEVINSSEN.—"Syst. overs. over de Nordiske Annulata." Vidensk. Meddelelser, Copenhagen, 1883.
- (4) MALAQUIN, A.—Les Syllidiens. Lille, 1893.
- (5) MESMIL, F., & M. CAULLERY.—"Les formes épitokes des Annélides." International Congress of Zoology, 1898.
- (6) SAINT-JOSEPH, Baron de.—"Sur les Annélides polychètes des côtes de Dinard." Ann. Sc. Nat. vol. xvii., 1894.
- (7) SCHRÖDER. — Anatomisch-histologische Untersuchung von *Nereis diversicolor*, O. Fr. Müll. Kiel, 1886.

## EXPLANATION OF PLATE 13.

(All the figures are of *Syllis vivipara*, Krohn.)

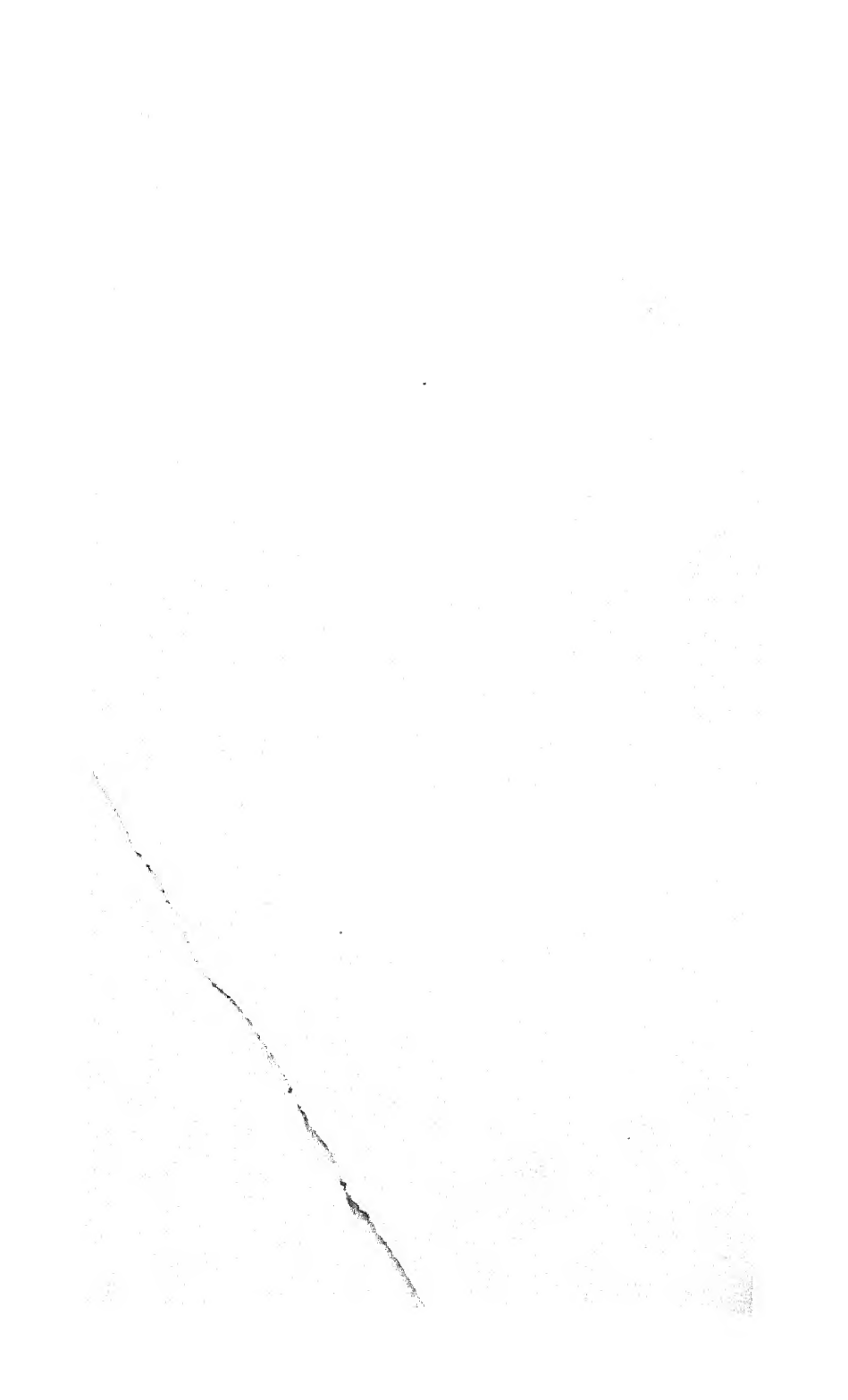
- Fig. 1. Enlarged dorsal view of an adult specimen containing several well-developed young. *d.c.*, dorsal cirri; *ph.*, pharynx; *i.*, intestine; *y.*, young.
2. Ventral view of the head, showing the mouth (*m.*) and palps (*p.*).
  3. Sketch of the pharynx in the extended condition.
  4. Ventral view of a portion of three posterior segments containing ova and developing embryos. *pp.*, parapodium; *s.*, septum; *i.*, intestine; *e.*, embryo; *d.c.*, dorsal cirri; *o.*, ovum.
  5. Transverse section of an adult worm, showing two embryos in the coelom. *w.*, body-wall; *i.*, intestine; *pp.*, parapodium; *y.y.*, young.
  6. Distal end of a chaeta.
-



E. S. Goodrich del.  
A. R. Hammond lith.

West, Henry, and sons

## REPRODUCTION OF SYLLIS VIVIPARA.



On the Structure of the Spermiducal Glands and Associated Parts in Australian Earthworms. By GEORGINA SWEET, M.Sc., Melbourne University. (Communicated by Prof. G. B. HOWES, Sec. Linn. Soc.)

[Read 21st June, 1900.]

(PLATES 14 & 15.)

IN the present somewhat unsatisfactory condition of the classification of the Australian earthworms, additional knowledge on important points in their anatomy is much needed. At the suggestion of Prof. Spencer, the following investigation has been carried out on what is one of the most constant and conspicuous organs in our Australian earthworms. This is the spermiducal gland, which is characteristic without exception of the indigenous forms in Australia.

In addition to this, the study has included the histology of the various accessory structures and ducts associated therewith, for while the general macroscopic structure in these forms has been well described by Prof. Baldwin Spencer and Mr. J. J. Fletcher, the microscopic details have been comparatively unknown, except in the one form, *Megascolides australis*, also described by Prof. Spencer\*. And here I would acknowledge my indebtedness to him for allowing me the use not only of his laboratory in the Melbourne University, but also of his large collection of Australian earthworms† and of literature thereon; also for much valued assistance on many occasions.

I have throughout made use of the generic divisions given by Beddard in his monograph of this group, this being the most easy means of reference.

The characteristic genera of earthworms in Australia are *Megascolides*, *Cryptodrilus*, *Diplotrema*, *Fletcherodrilus*, *Diporochæta*, *Megascolex*, *Digaster* (including *Didymogaster* and *Perissogaster* (Fletcher)), and *Acanthodrilus*. The 32 species examined include a number from Queensland, New South Wales, Victoria, and Tasmania.

The male reproductive organs in these forms, as is well known, consist typically of three parts:—(1) two pairs of testes, generally

\* Trans. Royal Society of Victoria, vol. i. pt. 1, 1888.

† The specimens of earthworms described by Mr. Fletcher were kindly sent by him to Prof. Spencer.

somewhat flat finger-like bodies attached to the anterior septum in segments 10 and 11. They are enclosed in a very delicate membrane connected with the peritoneal lining of the general body-cavity. The sperm mother-cells, which originate by multiplication of the cells of this peritoneal lining, pass out into (2) the seminal vesicles or sperm-sacs. These are generally found in pairs in segments 9 to 12, where they arise as out-growths of the septa, enclosing a small portion of the body-cavity. Here the sperm mother-cells develop so as to form by division the spermatozoa. These pass to the exterior by means of (3) two pairs of vasa deferentia. The latter open by means of two pairs of much-folded and ciliated funnel-shaped structures, from the segments in which the testes lie, and lead back through the following segments to open externally by a single pair of openings on segment 18, in the typical Australian Oligochæta. Associated with the external openings of these vasa deferentia are a pair of glands, the so-called "atria" or "prostates." The name "spermiducal glands," proposed for these glands by Beddard, is here retained as being the most appropriate. In addition, there are often present near the male pore other glands internally, or one or more "penial setæ."

These organs are in general constant throughout the group in many respects, but in detail they often vary widely in different species, both in structure and to a certain extent in position.

## A. MACROSCOPIC CHARACTERS OF THE SPECIES.

### I. MEGASCOLIDES.

#### 1. *M. INTERMEDIUS* \* (*Spencer*).

Only one pair of testes and of rosettes is present in this species. Sperm-sacs are found in segments 12 and 14.

The spermiducal glands (*sp.g.*, Pl. 14. fig. 3) are tubular in form and slightly coiled: they lie transversely to the body in segment 18, their ducts (*sp.d.*) opening on its external surface near the mid-ventral line. The duct of the spermiducal gland is almost straight and very muscular. The vas deferens on each side (*v.d.*) enters the gland-duct just where the latter leaves the gland.

Occupying the space internally, between and covering the two spermiducal ducts, and below the nerve-cord, is a white mass of

\* Proc. Royal Society of Victoria, 1892, p. 132: *Cryptodrilus intermedius* (*Spencer*). Beddard, 'Oligochæta,' p. 492.

glandular cells, which may extend through one, two, or even four segments (*a.g.*, fig. 3), or, on the other hand, may rarely be absent altogether. The surface of this glandular mass has a mottled brown appearance, due to small patches of pigment. Its presence in these segments probably depends on the state of maturity of the individual.

2. *M. VICTORIAE* \* (*Spencer*).

Two pairs of testes and rosettes are present in segments 10 and 11; the sperm-sacs are situated on the posterior wall of segment 9 and on the anterior wall of segment 12. The spermiducal glands (*sp.g.*, fig. 4) are long, regularly-coiled tubes occupying segments 18 to 26, or even 29, one coil to each segment. The spermiducal duct is long and muscular, running transversely in a double loop towards the ventral surface in segment 18, where it opens. The two vasa deferentia of each side remain quite distinct for their whole length. They run alongside the gland-duct for some distance, and pass straight through the substance of the lower part of the gland, entering the gland-duct just before it leaves the gland.

3. *M. INSULARIS* † (*Spencer*).

Testes and rosettes in segments 10 and 11.

Sperm-sacs in segment 9 (posteriorly) and segment 12 (anteriorly).

Spermiducal glands very long coiled tubes in segments 18 to 27; duct long, muscular, and but slightly curved. The two vasa deferentia on each side join before reaching segment 18, and the single vessel so formed runs in the muscular wall of the gland-duct, and so enters the duct about one-third of its length from the gland.

4. *M. HOBARTENSIS* ‡ (*Spencer*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs in segments 9 (posteriorly) and 12 (anteriorly).

The spermiducal glands are long and coiled, extending through segments 18 to 24 or 25. The muscular duct from each resembles closely that of *M. insularis*, being long and slightly curved. The vasa deferentia also unite on each side before they

\* Proc. Roy. Soc. Vict. 1892, p. 139: *Cryptodrilus victoriæ*, Spencer. Beddard, *loc. cit.* p. 488.

† *Ibid.* 1894, p. 41: *Cryptodrilus insularis*, Spencer.

‡ *Ibid.* 1894, p. 37: *Cryptodrilus hobartensis*, Spencer.

reach the level of the gland, the lower part of which they traverse, entering the spermiducal duct just as it leaves the gland.

5. *M. ATTENUATUS* \* (*Spencer*).

Testes and rosettes, two pairs in segments 10 and 11.

Sperm-sacs in segments 9 (posteriorly) and 12 (anteriorly).

Spermiducal glands are two tubular, slightly-coiled glands lying transversely in segments 18 and 19, each with a short straight muscular duct. The two vasa deferentia of each side remain separate, running up within the muscular wall of the spermiducal duct, and entering the duct as it leaves the gland.

On each side, just behind the opening of the spermiducal duct, is a slightly muscular sac enclosing a long curved penial seta. As in *M. intermedius*, there is on the ventral surface internally, below the nerve-cord and between the two spermiducal glands, a great mass of unicellular glands, which may occupy one to three segments.

6. *M. AUSTRALIS* † (*McCoy*).

In this form, which has been so completely described by Prof. Spencer, there are two, or occasionally three, pairs of testes and two pairs of rosettes.

The sperm-sacs are found in segments 11, 12, 13, and 14, on the posterior wall in each case.

The spermiducal glands are very much coiled, tubular structures in segment 18; the duct of each is much coiled above and straight as it passes through the body-wall, receiving as it does so the two vasa deferentia.

7. *M. ROSEUS* ‡ (*Spencer*).

Testes two pairs in segments 10 and 11 with rosettes.

Sperm-sacs in segment 12 on the anterior wall.

Spermiducal glands tubular and closely coiled, either confined to segment 18 or extending into the segments before and behind, *i. e.* 17 and 19 (*cf.* fig. 5). The duct of the gland has strongly muscular walls, and is slightly curved. The vasa deferentia on each side do not unite, although they lie close side by side, deep down in the body-wall. They enter the spermiducal duct about halfway along its length.

\* Proc. Roy. Soc. Vict. 1862, p. 155: *Megascolides attenuatus*, Spencer. Beddard, *loc. cit.* p. 491.

† McCoy, Prodrromus Zoology of Victoria, Decade 1. Spencer, Trans. Roy. Soc. Vict. vol. i. pt. 1, 1888. Beddard, *loc. cit.* p. 495.

‡ Proc. Roy. Soc. Vict. 1892, p. 154. Beddard, *loc. cit.* p. 491.

8. *M. TUBERCOLATUS* \* (*Fletcher*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs on posterior wall of segment 9 and on the anterior wall of segment 12.

Spermiducal glands tubular and very much coiled, lying transversely in segment 18. The gland-duct is long, and curved proximally into an S-shape; it is embedded chiefly in the body-wall.

The two vasa deferentia enter each gland-duct at the same point at about half the length of the latter.

On each side, lying between the spermiducal duct and the mid-ventral line, are a pair of small, slightly muscular sacs, each enclosing a long, somewhat robust penial seta, which pierces the body-wall close to and on the inner side of the male opening.

II. *CRYPTODRILUS*.9. *C. ILLAWARRÆ* † (*Fletcher*).

One pair of testes and of rosettes are seen in segment 11: one pair of sperm-sacs also on the anterior wall of segment 12.

The spermiducal glands are apparently somewhat long and straight flattened structures, lying transversely in segment 18. The gland-duct is short and straight, almost completely enclosed in the ventral body-wall, through which it runs vertically downward to open on the surface. The vasa deferentia are two in number on each side; not one, as might be inferred from the presence of only one pair of testes and rosettes. These run at varying levels, the anterior one in the muscle of the body-wall, the posterior one at its edge, until they reach the level of the posterior half of segment 13, when the upper one descends and runs alongside the lower one in the muscle-layer back to segment 18. They then join just outside the wall of the spermiducal duct, and the single one thus formed runs down in the substance of the wall to open into the duct close to its external opening. At the inner end of each gland-duct is a pair of short narrow sacs, nacreous in appearance, from the muscle-fibres in their walls, and each containing a long curved penial seta (s., fig. 24). These setæ are curiously hooked near their tips, and each opens independently of the others, through the body-wall,

\* Proc. Linn. Soc. N. S. W. 1887, p. 611: *Notoscolex tuberculatus* (Fletcher). Beddard, *loc. cit.* p. 494.

† *Ibid.* vol. iii. 1888, p. 1523. Beddard, *loc. cit.* p. 503.



on the inner side of, and sometimes slightly behind the male pores, and not through them as Mr. Fletcher has suggested.

10. *CRYPTODRILUS COORANIENSIS* \* (*Spencer*).

Two pairs of testes and of rosettes in segments 10 and 11.

Sperm-sacs in segments 7, 8, 9, and 12. Those in segments 7 and 8 appear to be sometimes absent in specimens otherwise similar. In segments 10 and 11 the testes are not visible as distinct structures from the so-called sperm-sacs, but are seen in section to be simply much denser parts of the ventral portion of these sacs, immediately in front of each of the rosettes, which are also enclosed within the sac, and surrounded by developing sperm (*cf.* fig. 15). These sacs in segments 10 and 11 thus appear to correspond to what Beddard has termed "sperm-reservoirs." In segments 10 and 11 the sperm-reservoirs, and in segment 12 the sperm-sacs, form complete rings around the alimentary canal, those in segment 10 being much larger and less definite in shape than the others.

The spermiducal glands are bilobed or flat, both varieties occurring in a single individual. Each gland-duct is short and thick, and receives at half its length the two vasa deferentia which have distinct openings into it, on opposite sides of the duct.

III. *DIPLOTREMA*.

11. *D. FRAGILIS* † (*Spencer*).

Two pairs of testes and rosettes in segments 10 and 11.

One pair of sperm-sacs on the anterior wall of segment 12.

The spermiducal glands are long, coiled tubes extending through segments 15 to 25, and opening as usual in segment 18 (*cf.* fig. 6). The posterior end of the gland is turned back through four or five segments. The gland-duct is somewhat less muscular than usual, and runs straight down to the surface, where it opens. The two vasa deferentia on each side remain distinct until they reach the level of segment 17, when they join and open to the exterior in segment 18 in front of and quite distinct from the spermiducal duct. On the internal surface of the ventral body-wall in segments 16 to 22, between the spermiducal

\* "Descriptions of Australian Earthworms," Part 1. Proc. Roy. Soc. Vict. vol. xiii. pt. 1.

† *Ibid.* vol. xiii. pt. 1.

ducts, is a glandular mass divided off into groups transversely by the septa, and supporting the nerve-cord. On the inner side of each spermiducal duct there are also a pair of slightly muscular sacs, each enclosing a curved penial seta. These open quite independently of each other and of the gland-duct, on the inner or ventral side of the latter.

#### IV. FLETCHERODRILUS.

##### 12. *F. UNICUS* \* (*Fletcher*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs in segments 9 and 10 (posteriorly) and 11, 12, and 13 (anteriorly). The gonads and rosettes appear distinct from the sperm-sacs in segments 10 and 11.

The spermiducal glands (*sp.g.*, fig. 2) are long tubular structures, lying transversely in segment 18, with the distal end somewhat coiled. Towards the mid-ventral line the tube becomes smaller and nacreous, marking the region of the duct, which then suddenly swells out, forming a well-marked muscular bulbus, straight through the centre of which runs the duct. Into this duct, at the level of the nerve-cord, there opens on each side a single vas deferens, which arises anterior by the union of the two ducts which leave the two rosettes. The ventral end of the sac passes beneath the nerve-cord and the longitudinal muscle-band, and meets its fellow of the opposite side in the mid-ventral line. Here they unite and form a strongly muscular duct, which runs vertically downward and slightly forward to open on a papilla in the mid-ventral line of segment 18. It is possible that this common part may be partially protrusible.

#### V. DIPOROCHEETA.

##### 13. *D. COPELANDI* † (*Spencer*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs in segments 9 (posteriorly) and 11 and 12 (anteriorly).

Spermiducal glands are long, coiled tubular structures, and may extend through segments 17 to 23, though sometimes less.

\* Proc. Linn. Soc. N.S.W. iii. (2) 1889, p. 1540: *Cryptodrilus unicus*, Fletcher. *Ibid.* iv. (2) 1890, p. 990: *Cryptodrilus purpureus* (Fletcher). Beddard, *loc. cit.* p. 481.

† Proc. Roy. Soc. Vict. 1892, p. 3: *Pericheta Copelandi* (Spencer). Beddard, *loc. cit.* p. 442.

The two vasa deferentia of each side remain quite distinct, though close together after segment 13. They enter the spermiducal duct, which is curved into a U-shape, near its external opening on segment 18. Close by, and on the inner side of each duct, and only visible under the microscope, are a pair of small and thin sacs, each containing two (or sometimes three) very fine, smooth, and slightly curved penial setæ, which open into the termination of the spermiducal duct by definite tubes lined with columnar cells.

14. *D. BAKERI* \* (*Fletcher*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs in segments 9 (posteriorly) and 12 (anteriorly).

Spermiducal glands are tubular, somewhat coiled, and extend through four segments, 18 to 21 (fig. 1). The gland-duct is long and slightly curved, and very muscular. On the inner side of each duct is a pair of small sacs, each containing a penial seta surrounded by muscle-fibres. The division between the gland and the duct is more sharply marked than usual. The two vasa deferentia of each side join at the level of the prostate just before they enter the muscular wall of the duct, and so open into the duct itself at about half its length. Into the last portion of the spermiducal duct open by a pair of well-defined tubes the two penial setæ, which are stouter than in *D. Cope-landi*.

VI. MEGASCOLEX.

15. *M. FRENCHI* † (*Spencer*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs in segment 9 (posteriorly) and segment 12 (anteriorly).

The spermiducal glands are flattened and bilobed, and are situated in segments 18 and 19, one lobe in each (fig. 8). The whole surface of the gland is divided up into irregular or polyhedral areas, which, as will be seen later, correspond with certain points of internal structure. The septum separating segments 18 and 19 is continued between the two lobes of the gland, and is pierced by the branch of the duct on its way to the main gland-duct. The main gland-duct, which is in segment 18,

\* Proc. Linn. Soc. N. S. W. ii. 1887, p. 616: *Perichæta Bakeri* (Fletcher). Beddard, *loc. cit.* p. 440.

† Proc. R. S. Viet. 1892, p. 9: *Perichæta Frenchi* (Spencer). Beddard, *loc. cit.* p. 379.

is formed by the union of two ducts, one from each lobe. The two vasa deferentia of each side unite in segment 13 to form one, which is larger in proportion than usual. This enters the spermiducal duct just at the union of its two main branches.

16. *M. FIELDERI* \* (*Spencer*).

A pair of rosettes in segment 11 are seen to be enclosed within a large membranous sac, in which, however, there was no indication of a testis.

Sperm-sacs in segment 12 are mushroom-shaped, and attached to the anterior wall by a definite stalk. In two specimens examined each sac was found to be filled with Gregarines.

The spermiducal glands are situated in segments 17 and 18; they are bilobed, one lobe in each segment (fig. 14). Occasionally a tendency to division into three lobes was seen in the larger and bifid character of the posterior lobe. The anterior is usually the smaller, and is often only united to the posterior one at the base by the branches of the gland-duct; while in other individuals again the gland is merely bifid, and confined to one segment. The surface of this gland, as in *M. Frenchi*, is divided up into numerous polygonal areas. The gland-duct is well marked, almost straight, and strongly muscular. As it passes down towards the ventral surface it curves slightly and enters a large hyaline muscular bulbus (fig. 14), within which the duct makes a double U-loop. The single vas deferens enters the muscular sac, and runs backwards and then alongside and behind the spermiducal duct, curving with it. The vas deferens joins the duct just after the latter has finally curved, to pass vertically downward to the external opening on segment 18. From its appearance, this last part of the spermiducal duct is probably protrusible. In one specimen, in which there was no prostate on one side, the vas deferens of that side simply ran straight to the surface in segment 18 without any increase of muscular fibres.

17. *M. TASMANICA* † (*Spencer*).

Two pairs of testes and rosettes in segments 10 and 11. The testes are large and finger-like.

Sperm-sacs in segments 9 (posteriorly) and 12 (anteriorly).

Spermiducal glands distinctly bilobed in segments 17 and 18; one lobe in each segment. In some individuals polygonal areas

\* Proc. R. S. Vict. 1892, p. 19: *Perichæta Fielderi* (*Spencer*). Beddard, *loc. cit.* p. 379.

† *Ibid.* 1894, p. 47: *Perichæta tasmanica* (*Spencer*).

were visible on the surface. The spermiducal duct is large though not always very long, and is muscular. It receives one main branch from each lobe, the main duct lying in and opening on segment 18. The vasa deferentia, two on each side, are very large in proportion to the size of the animal. They run close side by side just embedded in the body-wall until, in segment 12, those on the right side unite, while those on the left do not unite till segment 14. They enter the spermiducal duct close to the union of the branches from the two lobes.

18. *M. HOGGII* \* (*Spencer*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs in usual positions in segments 9 and 12.

Spermiducal gland in segment 18, bilobed and small; the surface appears smooth, without any markings. The duct is straight, or may be slightly curved, and is strongly muscular. The vasa deferentia, two on each side, enter the spermiducal duct close side by side, at about half its length.

19. *M. DENDYI* † (*Spencer*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs in segments 9 (posteriorly) and 12 (anteriorly).

Spermiducal glands in segments 18 and 19, may be flattened with but the smallest indication of a second lobe, or they may be clearly divided into two lobes (fig. 9). The surface of the gland is sometimes very much grooved, though not in any regular fashion, and having no relation to internal structure. The duct is single, *i. e.* it does not branch outside the gland-substance; it is long and curved into almost an S-shape in some cases, and at others forming three or four loops. The two vasa deferentia of each side remain quite distinct and enter the spermiducal duct side by side, just where it leaves the gland.

20. *M. DORSALIS* ‡ (*Fletcher*).

Two pairs of testes and rosettes in segments 10 and 11, both testes and rosettes being very large.

\* Proc. R. S. Vict. 1892, p. 6: *Perichæta Hoggii* (Spencer). Beddard, *loc. cit.* p. 379.

† *Ibid.* p. 12: *Perichæta Dendyi* (Spencer). Beddard, *loc. cit.* p. 380.

‡ Proc. Linn. Soc. N. S. W. vol. ii. 1887, p. 618: *Perichæta dorsalis* (Fletcher). Beddard, *loc. cit.* p. 376.

Sperm-sacs are conspicuous globular bodies in segments 9 (posteriorly) and 11 and 12 (anteriorly).

The spermiducal glands vary in position, and to a certain extent in shape. In one individual each was distinctly tubular, occupying segments 18 and 19, the wider portion in segment 19 being coiled. In this also the duct was very short, and completely embedded in the body-wall. In a second individual, the gland was much wider in proportion to its length, and appeared at first as a single flat elongated body in segments 18, 19, and 20, the duct forming a double-U curve. In the third specimen (fig. 10) the gland appears as a wide flat tube in segments 18, 19, 20 and 21; slightly curved in the first and last segments. The duct in this case was very short. The surfaces of the glands in the first and second individuals were quite smooth, apart from grooves incidental to curving. But in the third individual, the gland clearly showed an irregular division of the surface into areas exactly similar to those on the gland of *M. Frenchi*. The two vasa deferentia of each side enter the gland-duct on opposite sides at half its length from the exterior. The external opening is situated on a very strongly-marked papilla. In this papilla are situated two distinct sets of glands connected with the external openings.

21. *M. RUBRA* \* (*Spencer*).

Testes and rosettes, two pairs in segments 10 and 11.

Sperm-sacs in segments 9 (posteriorly) and 12 and 14 (anteriorly).

Spermiducal glands bilobed, lying entirely in segment 18, the posterior wall of which is pushed back. The spermiducal duct is long and coils slightly as it leaves the gland. The two vasa deferentia of each side unite about segment 13 to form one on each side, which runs up the wall of the spermiducal duct and enters it just inside the gland.

22. *M. MINOR* † (*Spencer*).

Segments 10 and 11 are occupied by what appear to be large sperm-sacs filled with masses of developing sperm. At the base of those near the nerve-cord on each side is a small spherical,

\* Proc. R. S. Vict. 1892, p. 8: *Perichæta rubra* (Spencer). Beddard, *loc. cit.* p. 379.

† "Descriptions of Australian Earthworms," Pt. 1. Proc. R. S. Vict. vol. xiii. pt. 1.

denser and more compact portion, which probably represents the true testis. The rosettes, though covered with sperm, were not seen to be included in the membrane enclosing the testes—though in other respects these agree with the sperm-reservoirs of Beddard.

The true sperm-sacs are very compact saccular structures in segments 9 (posteriorly) and 12 (anteriorly), and sometimes in 13 (anteriorly), those in segment 12 being the least saccular of the three.

The spermiducal glands are bilobed, or sometimes merely flat, and bifid structures in segment 18, the anterior wall of which becomes somewhat pushed out of position. The duct is small and S-shaped, and less muscular than usual. The vasa deferentia unite in segment 12 to form one on each side, which enters the spermiducal duct as it leaves the gland.

### 23. *M. INTERMEDIUS* \* (*Spencer*).

As in *M. minor*, though even to a more marked extent, the sperm-reservoirs are developed one on each side in segments 10 and 11, enclosing masses of developing sperm. The testes and rosettes, the latter of which are distinctly "Maltese-cross" in shape, are enclosed in the same membrane. In both segments each reservoir (*cf.* fig. 15) is divided off into two parts, the larger ventral part enclosing testis and rosette. The septum between segments 8 and 9 is lost, being merely represented by a few fibrous cords. Occasionally also, that between segments 9 and 10 is absent, in which case the sperm-reservoir of segment 10 is lost, the rosette alone being present. The sperm-sac usually found on the posterior wall of segment 9 is absent; a pair is present in segment 12 (anteriorly).

The spermiducal gland appears to be generally bilobed, with a strongly-marked U-shaped duct, the whole lying in segment 18. In one individual the gland on one side was flattened and irregular in shape, showing only a slight division into two parts. The duct was coiled, and the two vasa deferentia of that side opened into the duct a little way from the gland. On the other side the gland was absent, and the two vasa deferentia united in segment 18 and formed, with the addition of a thick wall of muscle-fibres, a duct corresponding in size and position with that on the other side.

\* "Descriptions of Australian Earthworms," Pt. 1. Proc. R. S. Vict. vol. xiii. pt. 1.

24. *M. ILLIDGEI* \* (*Spencer*).

Two pairs of testes and rosettes as usual in segments 10 and 11.

Sperm-sacs in segments 9 (posteriorly) and 12 (anteriorly). Spermiducal glands are bilobed and flattened, and wrap round the alimentary canal; their ducts are short but S-shaped.

The two vasa deferentia of each side unite only as they reach the level of the spermiducal duct. The single vessel thus formed enters the wall of the duct, and runs up in it, uniting with the gland-duct just as it emerges from the gland.

## VII. DIGASTER.

25. *D. ARMIFERA* † (*Fletcher*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs in segments 9 (posteriorly) and 12 (anteriorly). In one individual the whole of the segments 10 and 11 was filled with masses of developing sperm in which the rosettes were embedded. No definite membrane enclosed the mass, nor could any special representative of a testis be found, even in section; but it may probably be regarded as a sperm-reservoir. The size of the true sperm-sac in segment 12 is quite abnormal, and has almost completely closed up segment 13 by the pushing back of its anterior wall. The blood-vessels in this segment were also unusually large. In one specimen sperm-sacs were also present in segments 14 and 15 (anteriorly).

The spermiducal glands are present in segments 17, 18, and 19, or sometimes only in segment 18, which is then much extended. The glands are lobate, usually with three lobes more or less divided off. The whole surface is distinctly marked off into similar irregular areas to those seen in *Megascolex Frenchi*. The gland-duct is comparatively large and long, and is slightly curved (fig. 13). The two vasa deferentia of each side run very close together in the body-wall, and enter the spermiducal duct just after it leaves the gland.

Lying posterior to the gland-duct are two narrow sacs with slightly muscular walls. Each of these contains two well-marked penial setæ in a well-marked sheath. Each is curved and long, and is ornamented near the tip with numerous little short spines, as described by Mr. Fletcher, ending in a chelate point. The

\* "Descriptions of Australian Earthworms." Proc. R. S. Vic. vol. xiii. pt. 1.

† Proc. Linn. Soc. N. S. W. i. (2) 1887, p. 947. Beddard, *loc. cit.* p. 486.



setæ reach the surface through a small duct opening into the spermiducal duct just before that duct reaches the external opening.

26. *D. GAYNDAHENSIS* \* (*Spencer*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs large in segments 9 (posteriorly) and 11 and 12 (anteriorly). Spermiducal glands in segment 18 are small and flat. The duct is small and short, running straight down to the external opening on 18. The two vasa deferentia on one side join to form one duct near the gland. Those on the other side apparently remain distinct. In each case they traverse the substance of the spermiducal gland and run down inside the wall of the duct, with which they unite halfway to the exterior.

27. *D. MINOR* † (*Spencer*).

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs in segments 9 (posteriorly) and 12 (anteriorly)—in one specimen in segments 9 and 11. In segments 10 and 11 in the first specimen, the testes and rosettes were enclosed in true sperm-reservoirs.

The spermiducal gland is completely bilobed and not flattened: the duct is formed by the union of a branch from each half. The vasa deferentia, two on each side, having remained separate through their whole length, pass straight through the substance of the lower part of the anterior lobe of the spermiducal gland before entering the duct of that branch just before it unites with its fellow from the posterior lobe.

28. *D. BRUNNEUS* ‡ (*Spencer*).

One pair of testes in segment 10, and two pairs of rosettes in segments 10 and 11. The anterior rosettes are very small indeed.

Sperm-sacs in segment 12 (anteriorly).

Spermiducal glands larger than in *D. gayndahensis*, flattened and slightly bilobed. The duct is small and less muscular than usual, and runs straight into the body-wall. The two vasa

\* "Descriptions of Australian Earthworms," Proc. R. S. Vict. vol. xiii. pt. 1.

† *Ibid.* pt. 1, Proc. R. S. Vict. vol. xiii. pt. 1.

‡ *Ibid.* pt. 1, Proc. R. S. Vict. vol. xiii. pt. 1.

deferentia of each side remain quite distinct, and enter the spermiducal duct as it leaves the gland.

29. *D. SYLVATICA* \* (*Fletcher*),

Two pairs of testes and rosettes in segments 10 and 11.

Sperm-sacs are racemose structures in segments 9 (posteriorly) and 12 (anteriorly). This differs considerably from the original description, where the structures in segments 9 and 12 are called testes and described as "smooth and white bodies drawn out above into digitate processes tapering into fine points," while no sperm-sacs were mentioned whatever.

The organs in segments 9 and 12, here called sperm-sacs, and which have both the position and appearance of those structures in other forms, are conspicuous, white, and greatly mammillated. Also there are distinct digitate though small testes in their normal positions on the anterior wall of segments 10 and 11.

Spermiducal glands are bilobed and large. The duct is short and muscular, and embedded in the body-wall. The two vasa deferentia of each side enter the spermiducal duct as it leaves the gland.

30. *D. EXCAVATA* † (*Fletcher*).

In one specimen, testes and rosettes were present in segments 10 and 11.

The sperm-sacs were grape-like, in segments 9 (posteriorly) and 12 (anteriorly).

In this the spermiducal gland consisted of a long tubular structure, the anterior part lying in segment 18, considerably larger and flatter than the posterior part which extended back in segments 18 and 19. The duct leaves the gland at the beginning of the tube and is short, running down obliquely to open on the surface. The duct is less muscular than usual, and into it at the base of the gland opens the single vas deferens formed by the union on each side of the two vasa deferentia. On the inner side of the duct and opening into its lower portion are two slightly muscular seta-sacs, each containing one long seta.

In a second specimen there was no appearance of testes as distinct from the sperm-reservoirs, which occupied segments 10

\* Proc. Linn. Soc. N.S.W. vol. i. (2) p. 558: *Didymogaster sylvatica* (*Fletcher*). Beddard, *loc. cit.* p. 487.

† *Ibid.* vol. ii. (2) p. 383: *Perissogaster excavata* (*Fletcher*). Beddard, *loc. cit.* p. 486.

and 11 and enclosed the rosettes. The spermiducal gland was of a constant width throughout.

A third individual resembled the second in every respect, except that on one side the spermiducal gland was turned forward, lying in segment 18 entirely. As will be seen later, this differs somewhat from the original description. Around the spermiducal duct the body-wall is much thickened owing to the presence in it of groups of long unicellular glands, whose ducts open in groups on the surface around the male opening.

### 31. *D. QUEENSLANDICA* \* (*Fletcher*).

Two pairs of testes and rosettes in segments 10 and 11. Sperm-sacs very small in segments 11 and 12 (anteriorly). The spermiducal gland is flat in some specimens and well-developed (Pl. 14. fig. 11), while in others it appears to be either very small and tubular (fig. 12), or absent altogether, as in six specimens of those examined. In one of these specimens neither sperm-sacs nor testes could be seen, probably pointing to its immature condition. The two vasa deferentia, which along their length are separated by a short distance, enter the gland-duct quite separately at about half its length.

## VIII. ACANTHODRILUS.

### 32. *A. SYDNEYENSIS* (*Fletcher*).

One pair of rosettes in segment 11. Masses of sperm in segments 11 and 12, the first probably representing a sperm-reservoir, and the second sperm-sacs. Nothing comparable to a testis could be seen. The single vas deferens of each side runs back along the edge of the body-wall, and opens independently of the spermiducal glands on segment 18.

The spermiducal glands (*sp.g.*, Pl. 14. fig. 7) are two pairs of long, coiled tubular structures, one pair opening to the surface in segment 17, and the other in segment 19. Both extend back as far as segment 26. The muscular duct of each gland extends from its external opening back through about  $1\frac{1}{2}$  segments, and then passes into the second region which extends through another  $3\frac{1}{2}$  segments, while the most distal glandular region is found in the last three of these segments. The glands lie near the nerve-cord on each side, passing through the ventral opening in the septa with the nerve-cord and ventral blood-vessel.

\* Proc. Linn. Soc. N. S. W. vol. iii. (2) p. 1529: *Perissogaster queenslandica* (Fletcher). Beddard, *loc. cit.* p. 485.

## B. GENERAL MACROSCOPIC FEATURES.

I. *Testes and Sperm-sacs.*

The position of the testes in segments 10 and 11 appears nearly constant throughout the Australian genera. Occasionally we find that there is but one pair of testes, in which case it is situated in segment 11, e. g. *Cryptodrilus illawarræ* and *Megascolides intermedius*, or rarely in segment 10 as in *Digaster brunneus*. Rarely less than two pairs of rosettes are present, e. g. *Megascolex Fielderi*, *Cryptodrilus illawarræ*, and *Megascolides intermedius*; though the anterior pair may be very small (e. g. in *Digaster brunneus*). Very often, as in *Megascolex intermedius*, *M. minor*, *Digaster minor*, and *Cryptodrilus cooraniensis*, the testes or rosettes, or both, are enclosed within sperm-reservoirs. There is, when present, one of these structures on each side in contrast to the median position of the typical "sperm-reservoirs" to which the name was originally given by Beddard. Each reservoir may or may not be divided by a connective-tissue septum into two or more chambers (cf. s. r. Pl. 14. fig. 15), the ventral of which is larger and contains the rosette (r.), and also the denser, more compact, and more darkly-staining portion, which represents the testis in such cases except in *Digaster armifera*, where it is absent. The rosette is, rarely, not enclosed in this sac, when it is present, as in *Megascolex minor*; but since it nevertheless contains the "testis," it may be regarded as answering to Beddard's definition of a "sperm-reservoir" as a sac enclosing the gonads and the rosettes. The true sperm-sacs are usually found on the posterior wall of segment 9, and on the anterior wall of segment 12. In addition to this, there is sometimes a pair of true sperm-sacs in segment 11, e. g., in *Digaster gayndahensis*, *Diporochæta Cope-landi*, and *Megascolex dorsalis*. Sometimes that in segment 12 only may be present, as in *Digaster brunneus*, *Megascolex Fielderi*, *Cryptodrilus illawarræ*, *Diplotrema fragilis*, and *Megascolides roseus*. In other forms, that in segment 9 may be absent, and present in segments 11 and 12, e. g. *Digaster queenslandica*. In *Megascolex rubra* they are found in segments 9, 10, and 14; in *Megascolides australis* in 11, 12, 13, and 14; in *Megascolides intermedius* in 12 and 14; in *Digaster armifera* in 9, 12, 14, and 15; and in *Fletcherodrilus unicus* in segments 9, 10, 11, 12, and 13. Those occurring in segments 9 and 10

are attached to the posterior wall of the segment, and those in segments behind 10 to the anterior wall of the segment. These sperm-sacs vary in form as well as in position. Sometimes they form definitely shaped masses enclosed in a firm membrane. In this case, they are simply lobed or mammillated, or form a ring around the alimentary canal. At other times they are much looser, racemose structures, when the investing membrane is easily broken. Again, the whole cavity of the segment may be completely filled by a mass of seminal cells, obliterating the cavity of the succeeding segments by backward pushing of the septum. In several instances Beddard has cast doubt on the character of the sacs in segments 13 and 14 when so existing, preferring to regard them as egg-sacs rather than sperm-sacs as described. In no species which I have examined has there been any sign of ova in such a position, these sacs invariably containing developing sperm.

## II. Spermiducal Glands.

These are usually found in segment 18 and sometimes in contiguous segments, only very rarely extending in front of segment 18. The two main types of external form are tubular and lobate (including flat and undivided forms).

(1) *Tubular Glands*.—These lie either transversely to the body, when they are generally confined to segment 18; but in some species they may, when mature, extend as far back as segment 26. They are usually slightly coiled, but in some cases, e. g., *Megascolides roseus* and *M. australis*, they are twisted into an almost inextricable mass, lying in segment 18. They are characteristic of the following genera:—*Megascolides*, *Cryptodrilus* (partly), *Fletcherodrilus*, *Diporochæta*, and *Acanthodrilus*. With regard to *Digaster*, it will be noted that the two species *D. excavata* and *D. queenslandica* are somewhat different from the remainder of the genus, more especially the former species. They have been described as bilobed, with a flattened lobe anteriorly and a long tubular portion posteriorly. In the specimens of *D. excavata* examined by me only tubular “prostates” have been seen, though in one individual a band of connective-tissue in the position described for the gland-duct might possibly be mistaken for a duct. It, however, does not contain any duct whatever, the true gland-duct leaving the

front end of the tubular gland. In *D. queenslandica*, as before stated, the majority of specimens have no spermiducal gland; in others it is a small, shortened, flattened tube (fig. 12), while yet another has a large well-developed flattened single lobe (fig. 11). In *Cryptodrilus illawarræ* the gland forms, as will be seen later, a transitional stage between such a tubular gland as that of *Diplo-trema fragilis* and the second group of forms. In *Acanthodrilus sydneyensis*, as is typical of the genus, there are two pairs of tubular prostates lying longitudinally. The first pair open on segment 17, and the second pair on segment 19, and both run backwards, coiling somewhat as they go, as far as segment 26.

(2) *The Lobate Glands*, including single-lobed, bilobed, and trilobed forms, are characteristic of the remaining genera, viz., *Megascolex Digaster* (excluding *D. queenslandica* and *D. excavata*), and *Cryptodrilus*.

Among these, the external form of the gland in *Megascolex dorsalis* would suggest the possibility of its being an intermediate condition between the tubular and lobate forms, as also that of *Cryptodrilus illawarræ* (vide infra). These glands usually occupy but one segment, that in which they open, 18; but often the posterior lobe is found in segment 19 separated from the anterior lobe by the septum between these two segments.

### III. *Ducts* (Vasa Deferentia and Spermiducal Ducts).

There is a certain amount of variation in the arrangement of each of these ducts, and in their relations one to the other.

(1) *The Spermiducal Duct*.—The main part of the duct, which is usually well supplied with circular muscles, both in the lobate and tubular forms, may be—(1) short and straight or but slightly curved: e. g., *Megascolex tasmanica*, *M. Hoggii*, *Diporochæta Copelandi*, *Cryptodrilus cooraniensis*, *Megascolides intermedius*, *M. attenuatus*, *Digaster minor*; occasionally being confined entirely within the body-wall, e. g., *Digaster brunneus*, *D. gayndahensis* from Queensland, and *Cryptodrilus illawarræ*. (2) It may be long and more or less curved, sometimes but slightly, as in *Megascolides roseus*, *M. victoriæ*, *M. insularis*, *M. hobartensis*, *Megascolex rubra*, and *Diporochæta Bakeri*; at other times it is much longer, forming a U-shaped loop, e. g. *Megascolex intermedius*, or, again, forming a double loop as in *Megascolex dorsalis* and *M. Dendyi*, &c. (3) In the lobate forms

the main duct may either (a) leave the substance of the gland before the branches from the separate lobes have united, as in *Megascolex Frenchi*; or (b) it may leave the gland as a single duct, as in the great majority of cases, e. g., *Megascolex Dendyi*, *M. tasmanica*, or *Digaster armifera*.

Another variation connected with the spermiducal duct is in the presence of a muscular swelling or bulbus on each side in *Megascolex Fielderi* and *Fletcherodrilus unicus*. In the latter it partakes more of the nature of a swelling caused by an enormous and somewhat sudden thickening of the muscular layer of the duct-wall, straight through which the duct runs on its way to join its fellow of the opposite side, and open to the surface. In *Megascolex Fielderi*, however, it is different. The bulbus is almost spherical (m.b., Pl. 14. fig. 14), and similar in size to that in *F. unicus*. The duct is sharply bent just before it enters the side of the bulbus, which it does obliquely. Within the bulbus the duct makes a complete coil, the vas deferens accompanying it until it opens into the duct a short distance from the external opening.

(2) *Vasa deferentia*.—In accordance with the usual presence of two pairs of rosettes, there are generally two pairs of vasa deferentia. Even when the second pair of rosettes is absent, the two vasa deferentia are usually present on each side. Rarely there may be only one pair of vasa deferentia, e. g., *Megascolides intermedius* and *Megascolex Fielderi*. They may join when there are two on each side as soon as possible after the 11th segment, i. e. in the 12th, e. g., *Megascolex tasmanica*, *M. minor*; or they may unite in the 13th or 14th segments, not always at the same level on the two sides, e. g., *Fletcherodrilus unicus*, *Megascolex Frenchi*, *M. rubra*. They may join just before they reach the spermiducal duct, as in *Megascolides insularis*, *M. hobartensis*, *Cryptodrilus illawarrae*, *Diplotrema fragilis*, *Diporochæta Bakeri*, *Megascolex Illidgei*, *Digaster gayndahensis*, *D. excavata*; or they may join as they enter the duct, e. g., *Megascolides attenuatus*, *M. australis*, *M. tuberculatus*, *Diporochæta Copelandi*, *Megascolex Hoggii*, *M. Dendyi*, *M. intermedius*, *Digaster armifera*, *D. sylvatica*, *D. minor*, *D. brunneus*; or they may open into the duct quite independently of each other, e. g., on opposite sides of the duct—such are *Megascolides victoriae*, *M. roseus*, *Cryptodrilus cooranensis*, *Megascolex dorsalis*, *Digaster queenslandica*.

Variations in the relations of the spermiducal duct to the vasa

deferentia fall into four groups. (1) Those forms in which they unite just where the gland-duct leaves the gland, e. g., *Megascolex tasmanica*, *M. Dendyi*, *M. rubra*, *M. minor*, *M. intermedius*, *M. Illidgei*, *Megascolides intermedius*, *M. attenuatus*, *Digaster armifera*, *D. excavata*, *D. minor*, *D. brunneus*, and *D. sylvatica*. Sometimes the vasa deferentia traverse the substance of the lower part of the spermiducal gland before they join the gland-tube, e.g., in *Digaster minor*, *Megascolides victoriæ*, *M. hobartensis*, and *Megascolex rubra*. (2) Those in which the vasa deferentia enter the gland-duct at some point along the length of the latter: e. g., *Megascolex Frenchi*, *M. Fielderi* ( $\frac{2}{3}$ ), *M. dorsalis* ( $\frac{1}{2}$ ), *M. tasmanica*, *M. Hoggii*, *M. Dendyi* ( $\frac{1}{2}$ ), *Diporochæta Copelandi* ( $\frac{2}{3}$ ), *D. Bakeri* ( $\frac{2}{3}$ ), *Fletcherodrilus unicus* ( $\frac{2}{3}$ ), *Megascolides insularis* ( $\frac{1}{3}$ ), *M. australis*, *M. roseus* ( $\frac{1}{2}$ ), *M. tuberculatus*, and *Digaster queenslandica*, *D. gayndahensis*, and *Cryptodrilus cooraniensis*. (3) Those forms in which they join just before the external opening, or they may even open together on the surface, e. g., *Cryptodrilus illawarræ*, and sometimes *Diporochæta Copelandi*. (4) Those in which the vasa deferentia open quite independently of the spermiducal openings, e. g. *Diplotrema fragilis*—in front, but on the same segment; and in *Acanthodrilus sydneyensis*, on different segments.

It will be seen from the examples given in the second group, that there are several exceptions among these Australian forms to the statement made by Beddard that the vasa deferentia enter the gland-duct at its commencement in the Perichætidæ.

Associated with these ducts are to be seen, in certain genera and species, penial setæ. These are usually situated two on the inner side of each spermiducal duct. They are enclosed in a sheath within slightly muscular sacs—usually each sac only contains one seta, e.g., in *Megascolides attenuatus* (one on each side of the body), *M. tuberculatus*, *Cryptodrilus illawarræ*, *Diporochæta Bakeri*; but sometimes there may be two or even more in each sac, e.g., in *Diporochæta Copelandi* and *Digaster armifera*. These setæ may open by definite ducts into the cavity of the spermiducal duct and so reach the surface, e.g. in *Diporochæta Bakeri*, *D. Copelandi*, and *Digaster armifera*. At other times they simply protrude straight through the body-wall, independently of the duct, e. g., *Diplotrema fragilis*, *Megascolides tuberculatus*, *Cryptodrilus illawarræ*. They are larger than usual in *Megascolides tuberculatus*, *Diporochæta Bakeri*, and *Digaster*



*armifera*, and thinner than usual in *Diporochæta Copelandi*. In all, except *Cryptodrilus illawarræ* and *Digaster armifera*, they are smooth and slightly curved. In *C. illawarræ* (Pl. 15. fig. 24) they are curiously bent back or recurved near the tip; while in *Digaster armifera* (as already described by Mr. Fletcher) the tip is beset with five spines, and ends in a double chelate joint.

## C. HISTOLOGY.

### I. Spermiducal Glands.

Typically each gland is a hollow structure, the body-wall being composed of long glandular cells, with a columnar cell-lining and covered by peritoneal membrane. Though there are considerable differences in the microscopic structure of the spermiducal gland in various forms, yet there is a certain amount of constancy in the relations of the external and internal structure of the gland. Thus the variations in its histology fall chiefly into two main groups, corresponding (1) to the tubular forms, and (2) to the lobate forms.

1. *The Tubular Forms* (Pl. 14. fig. 16).—Here there is a central duct running the whole length of the gland, and directly continuous to the exterior. This duct is lined throughout by epithelium generally of ordinary columnar cells (*c.e.*), with a nucleus at the inner end of each (fig. 17), or sometimes of cubical cells (fig. 16). The inner ends of the cells are usually more or less horny, while the nuclei are usually clearly visible even when the boundaries of the cells are not so (fig. 17). In *Megascolides australis*, however, as previously described by Professor Spencer, these lining-cells are more granular in appearance, staining deeply and rarely showing any nuclei. Outside this lining is often a small amount of connective-tissue with small blood-vessels. The outermost layer of the wall of the duct making up the bulk of the gland is composed chiefly of coarsely granular gland-cells (*g.c.*, Pl. 14. fig. 16 & Pl. 15. fig. 17). Each of these has a pear-shaped outer end, containing a nucleus often pushed to one side: it has a long narrow duct-like inner end which opens into the lumen of the gland, between the cells of the columnar lining—sometimes singly, *e.g.*, in *Megascolides roseus*, *M. australis*, *M. attenuatus*, *M. insularis*, *M. hobartensis*, and *Diploptrema fragilis*; and sometimes in groups, especially where the lining is at all horny, *e.g.* in *Megascolides intermedius* (fig. 17),

*M. victoriae*, *M. tuberculatus*, *Digaster excavata*, *Fletcherodrilus unicus*, *Diporochæta Copelandi*, and *D. Bakeri* (occasionally in the latter they appear singly).

In some forms there are a limited number of cells which are generally scattered and are similar to the gland-cells around them, except that they are more granular and stain very much more readily with methylene-blue than the others, and are therefore very conspicuous, *e. g.* in *Megascolides victoriae* and *Fletcherodrilus unicus*, in both of which cases they are very numerous; also in *Digaster armifera* and *Diporochæta Bakeri*. At other times similarly staining cells form a more or less distinct layer at about half the thickness of the wall of the gland. These cells have a more rounded club-shaped end than the ordinary gland-cells, and are very well-marked in *Megascolides insularis* (Pl. 14. fig. 16) and *M. hobartensis*. The blood-vessels in these forms are sometimes found in the connective-tissue immediately around the columnar-cell lining; but often the main blood-vessel runs down the side of the gland, branching there and sending in fine capillaries amongst the glandular cells (*b.v.*, Pl. 15. fig. 17). The forms *Cryptodrilus illawarrae*, *Megascolex dorsalis*, and *Digaster excavata* will be described with the lobate forms.

In *Acanthodrilus sydneyensis* (Pl. 15. fig. 18) the structure of the three parts of each tube is as follows:—The proximal part is the gland-duct (fig. 18 *a*), which as usual is lined by columnar cells, the cell-outlines being rarely seen while the nucleus is large and distinct. The muscle-layer forming the thickness of the wall (*c.m.*) is composed, as in other forms, chiefly of circular fibres.

The next part forms an intermediate region between the duct and the glandular part proper. The lining of non-glandular epithelial cells is continued back from the duct (fig. 18 *b*). The glandular cells (*g.c.*) are quite distinct in appearance from those previously described. They are almost columnar in shape, with an inner slightly rounded end and a nucleus near their outer end, surrounded by the granular cell-contents. This is succeeded by the third and most distal part (fig. 18 *c*)—the most glandular. This is most striking in appearance, owing to the rapidity with which the cell-contents stain in methylene-blue, as may be seen on reference to the figure, where it is indicated by the depth of the shading. The facts show that the deeply-staining material (mucous or other secretion) is situated variously at the inner or outer end of the cell; and it may be

inferred that in the latter case it has not yet made its way to the cavity of the gland; while in the former it is just about to be passed out into that cavity, as the outer part of the cell in these cases is very finely granular, and does not take the methylene-blue at all readily. The cells are much larger than those seen in other forms, and, by the irregularity in shape of their inner ends, they make the cavity of the gland in this region very uneven, though of greater calibre than the intermediate portion. The blood-vessel runs up alongside the wall of the gland and branches on the surface. It will be found that this differs considerably from the description given by Beddard of the spermiducal gland of *Acanthodrilus* among other genera. *Acanthodrilus* is described by him as being similar to other genera of Megascolidæ, such as those having tubular spermiducal glands, *i. e.* the Cryptodrilidæ and Perichætidæ, and all but one of the Acanthodrilidæ. That this is not so in this species is evident. In the first place, the cells of the columnar lining, even in the intermediate portion, are not granular, the nucleus only being generally visible, and indeed this is by no means a constant character in many of the genera, as before described. There is further no columnar-cell lining at all in the glandular part proper of this Acanthodrilid. Again, the glandular cells here are quite distinct in shape and appearance from the pear-shaped cells with long duct-like inner ends, found so constantly in such genera as *Megascolides*, *Diporochæta*, and the ordinary Acanthodrilids. They are here moreover only one layer thick. Even in the intermediate portion the gland-cells are more like those in the glandular part proper, than like those found in the genera above named.

2. *The Lobate Forms*.—These show in microscopic section a distinct and characteristic lobular arrangement, typically without any central tube. The lobules are more or less well-defined accordingly as the whole gland is less or more compact, since in the more closely-packed glands the cells of contiguous lobules have a tendency to overlap, thus masking to a certain extent the radiate appearance so conspicuous in the looser forms. The lobules, especially in the latter case, are separated by a small amount of connective-tissue (Pl. 15. fig. 19). In this there run the blood-vessels of the gland (*b.v.*), which are often very numerous and definite, *e.g.* in *Digaster brunneus*, and at other times have more the nature of lacunæ; the very fine terminal branches of the

gland-duct are also to be found in this connective-tissue. The latter are lined by a well-marked cubical epithelium surrounded by a few muscle-fibres. Each lobule has typically a radiate appearance, with sometimes a small lacuna or space (*ll.*) in its centre, *e. g.* in *Megascolex Dendyi*, *M. tasmanica*, and *M. dorsalis*, which is however generally obliterated by the approximation of the inner ends of the cells. In very rare cases, a communication can be traced between it and one of the terminal branches of the gland-duct (as in fig. 20). In no instance was an epithelium of any kind to be seen around the central lacuna. The cells forming the substance of the lobules are of three kinds:—(i) The chief are those having the appearance of ordinary long narrow gland-cells with swollen outer ends, which contain large darkly-staining granules with generally a nucleus. (ii) The second group of cells are a number which appear to be quite empty and rarely showing a nucleus: they are probably simply cells which have discharged their contents into the gland-duct. (iii) Here again in some forms, *e. g.* *Megascolex Frenchi* and *Digaster queenslandica*, we find the cells seen in the tubular forms which stain readily with methylene-blue, and which serve here to accentuate the radiate appearance of the lobules, especially in *D. queenslandica*. The inner ends of the first and second sets, and of the third when present, come together in the centre of the lobule and evidently pour their contents into the gland-duct by means of the lacuna and duct before mentioned.

As before stated, the three species *Cryptodrilus illawarræ*, *Megascolex dorsalis*, and *Digaster excavata*, are intermediate forms between the tubular and lobate glands. In the two former there is a well-marked central duct running the whole length of the gland (fig. 24), and lined by columnar cells with a cuticular edge as usual in tubular forms. The main mass of the gland, however, is made up of lobules sometimes indistinctly separated from one another. In the centre of each lobule is a lacuna, which is connected with the central duct by a complex series of branches. Blood-sinuses run between the lobules. In *Digaster excavata* the branching is very much less complicated. There is but one series of branches from the central tube to form lobules, which are sometimes but seven or eight in number in the circumference of the gland. The central duct with its columnar lining is very conspicuous. It will be noted that this intermediate character agrees entirely in the first two cases with

what might have been expected from the external form, for it is often difficult to know to which group to refer the glands in these species by merely examining the outside of the gland.

## II. Accessory Glands.

(1) Glands found within the coelom, as in *Megascolides intermedius*, *M. attenuatus*, and *Diploptrema fragilis*. These include two distinct types. In *Megascolides intermedius* and *M. attenuatus* the glandular masses occupy the internal surface of the ventral body-wall between the spermiducal ducts. In the former, *M. intermedius* (Pl. 14. fig. 3), these structures (*a.g.*) vary in the number of segments they occupy, *e.g.* from two to four segments, or they may even be absent altogether. In *M. attenuatus* they were found to occupy three segments—17, 18, 19. They consist (Pl. 15. fig. 21) of a mass of long unicellular glands covered by the thin peritoneal membrane; the gland-cells have pear-shaped outer ends, with granular contents and distinct nuclei. The long narrow duct-like inner ends of these cells (*g."c."*) run down through the longitudinal and circular layers, and open on the ventral surface between the columnar cells of the epidermis. In *M. attenuatus* the gland-cells at the sides of the mass are much (sometimes two or three times) longer than those in the centre, otherwise they resemble those in *M. intermedius*. In each case the nerve-cord runs above, and is supported by the glandular mass. In *M. intermedius* (fig. 3) the surface is seen to be mottled, owing to the presence of small patches of brown pigment.

*Diploptrema fragilis* (Pl. 15. fig. 22).—Here the gland-mass takes up the ventral surface of segments 16 to 20 or 21. It is divided up transversely by the septa which traverse it. In segment 18 the spermiducal duct runs down alongside this accessory gland-mass to open on the surface. In microscopic structure the gland-mass is very different from that in *Megascolides intermedius*. It is composed of a number of groups, a central one on which rests the nerve-cord, and two others on either side of this (*cf.* fig.). Each contains a central cavity which is lined by a single row of very granular cells varying somewhat in size, each with a nucleus. The cavity of the central group is somewhat irregular, while its floor is formed by the layer of longitudinal muscles on which are situated gland-cells. Each of the lateral groups has a definite opening to the exterior through the

body-wall (fig. 22, *a'*), but no opening could be seen in relation to the central group. It is probable, however, that this opens by means of a communication with the duct leading from the inner of each set of lateral groups. Each group is surrounded by a distinct layer containing muscle-fibres. This doubtless assists the propulsion of the secretion outwards. Between each of the two lateral groups on each side and between them and the central group, in the region of the spermiducal-duct opening, is a muscular sac (*s.s.*) containing a large curved but smooth penial seta (*s'*). There are thus two of these on each side, and the gland-groups open, not around the opening of the spermiducal duct, but around the penial setæ. This will be clear on a reference to the figure.

(2) Glands embedded in the body-wall, *e. g.* *Megascolex dorsalis* and *Digaster excavata*. In *M. dorsalis* (Pl. 15. fig. 23) there are two completely different sets of glands separated by the spermiducal duct. The first and upper of these (*a'.g.'*), which lies to the outer side of the spermiducal duct, is composed of a number of alveoli. Each alveolus contains a central cavity surrounded by large finely granular gland-cells, each with a nucleus pushed to its outer edge. The alveoli are separated from each other by a number of connective-tissue septa. No connection could be traced between these and the gland-duct, though from their position it is probable that they do, at times, open into the spermiducal duct. The second set are those (*a.g.*) to be found on the inner side of the gland-duct. They are much lower down in the papilla. The cells of these groups are much smaller and clearer, though arranged as before around a central space. Each group opens on the surface not by means of a single duct, but by a number of fine ducts from the gland-cells forming the group. These run down and open to the surface between the columnar cells of the epidermis. It is the latter set only which are found in *Digaster excavata*. In this form the groups are more numerous, but more scattered and looser in structure. The groups of unicellular ducts, which are longer than in *Megascolex dorsalis*, are to be seen very clearly opening on the surface. One or two groups open into the spermiducal duct, close by the opening of the setæ into the latter.

*Summary.*

It will be seen from the above description that there is, in these species, a continuous series of forms of increasing complexity in internal structure. Commencing with the tubular forms, we have first those in which the gland-cells open into the lumen between the columnar cells of the lining (Pl. 14. fig. 16). There is here obviously a very close resemblance in structure to the clitellum or to the special accessory gland in *Megascolides intermedius* and *M. attenuatus*, if we neglect the occurrence of the muscle-layers there. Next we have those forms in which perhaps, on account of the increase in cornification of the lining epithelium, the gland-cells open into the lumen in groups (Pl. 15. fig. 17). The next stage is seen in such a form as *Digaster excavata*, where the lumen gives out a single series of branches, each of which bears at its end a group of gland-cells, which is thus situated at about half the thickness of the gland-wall. Here, however, the columnar lining of the main duct is not continued up these branches (cf. *Digaster excavata*).

Further complication is met with in such forms as *Megascolides illawarræ* and *Megascolex dorsalis*, where the main duct all along its length branches considerably more than in *Digaster excavata*, and here to a great extent the branches are lined by cubical cells continuous with the columnar lining of the main duct (Pl. 15. fig. 24); but here also there is no cell-lining to the fine terminations of the branches. From these we pass to such highly complex forms as, for example, *Megascolex tasmanica*, *M. Frenchi*, in which the main duct breaks up immediately it enters the gland, so that there is no central tube in these lobate forms (Pl. 15. figs. 19 & 20). Corresponding with this, the branching is still further increased, and as a result the lobules become more closely compacted together and fill up the entire interior of the gland. Consequent on this increase in branching, the groups are much more numerous and are pushed out towards the periphery, so that the mass of the gland is made up of these groups, the cells in which become more closely pressed together and their ducts much shortened. The blood-vessels which originally ran along the surface of the gland, or just outside the lining of the duct, have become much branched corresponding with the branching of the duct, and serve very often, with the small

amount of connective-tissue in which they run, to separate lobule from lobule, at the same time sending branches into them between the cells, to which they supply materials for secretion.

The result of this investigation into the structure of the spermiducal glands of an entirely different series of species from those studied by Beddard, clearly corroborates the statement that the more complicated lobate forms are derived in a comparatively simple way from the tubular.

*Acanthodrilus sydneyensis*, however, differing as it does so markedly from the *Acanthodrilidæ* generally, cannot be referred to the consecutive series at all.

### Conclusions.

The following are the more important conclusions arising out of this paper :—

1. That for the glands in question there is a correspondence between internal structure and external form.
2. That there exists a complete series of conditions connecting the simplest tubular form with the most complex lobular.
3. That a cell-lining is absent from the finest terminations of the duct.
4. That the structure of the accessory glands in *Diploptrema fragilis* is peculiar, and that of the spermiducal gland in *Acanthodrilus sydneyensis* unique.

### EXPLANATION OF THE PLATES.

#### Reference Letters.

<i>a.g.</i> , accessory glands.	<i>l.m.</i> , longitudinal muscle-band.
<i>a.g.</i> , upper accessory glands.	<i>l.l.</i> , lacuna in centre of lobule.
<i>b.v.</i> , blood-vessel.	<i>m.b.</i> , muscular bulbus.
<i>c.e.</i> , columnar epithelium.	<i>n.c.</i> , nerve-cord.
<i>c.l.</i> , cuticular layer.	<i>p.</i> , peritoneum.
<i>c.m.</i> , circular muscle-layer of body-wall.	<i>r.</i> , ciliated rosette.
<i>c.m.</i> , circular muscle-layer of gland-duct.	<i>s.</i> , penial seta.
<i>c.t.</i> , connective-tissue.	<i>s.s.</i> , setal sac.
<i>g.c.</i> , gland-cells.	<i>s.r.</i> , sperm-reservoir.
<i>g.c.</i> , special club-shaped gland-cells.	<i>sp.d.</i> , spermiducal duct.
<i>g.c.</i> , duct of gland-cell.	<i>sp.d.</i> , fine branches of spermiducal duct.
<i>l.m.</i> , longitudinal muscle-layer.	<i>sp.g.</i> , spermiducal gland.
	<i>v.d.</i> , vas deferens.

The outlines of all the figures have been drawn beneath the camera lucida, and on pl. 14 the position of the vas deferens is in all cases indicated by dotted lines.



## PLATE 14.

Fig. 1. Spermiducal gland on left side of *Diporochæta Bakeri*, showing spermiducal duct and two setal sacs.  $\times 6$ .

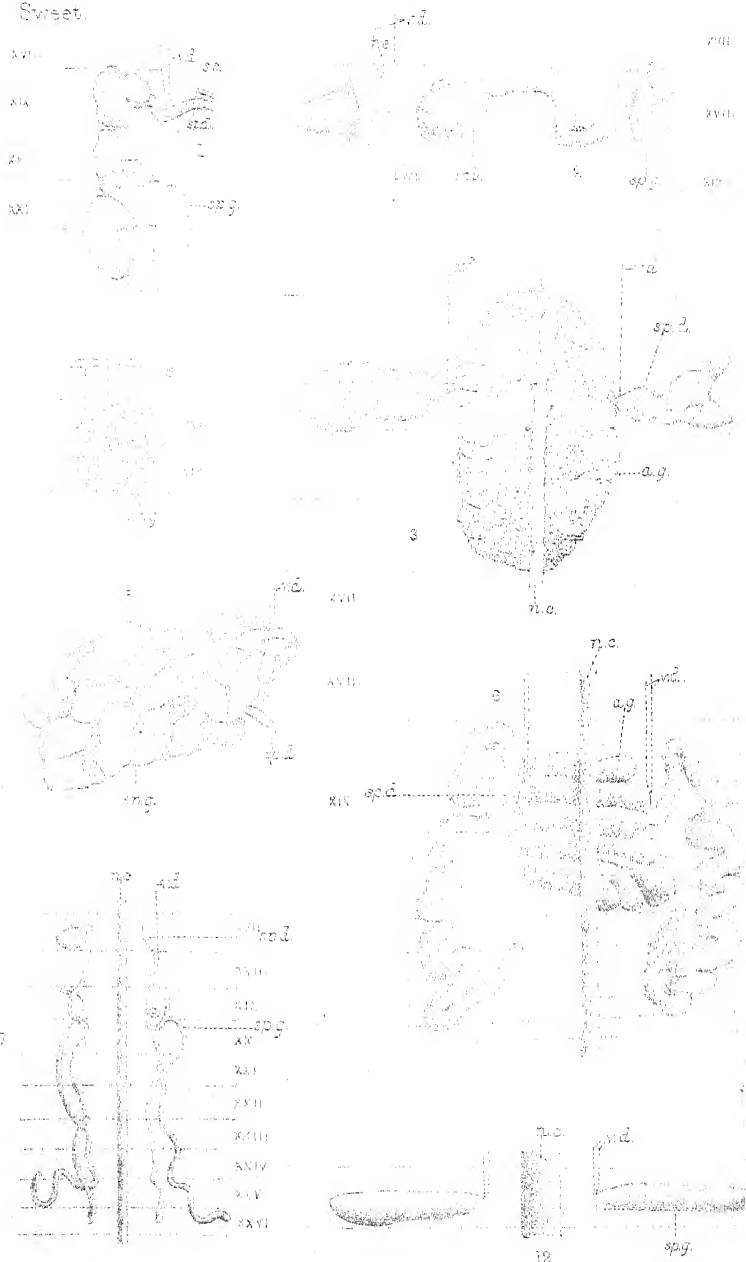
2. *Fletcherodrilus unicus*. Spermiducal gland of right side. The muscular bulbus (*m.b.*) is seen on each side to run under the ventral longitudinal muscle-band (*l.m.*) which supports the nerve-cord (*n.c.*).  $\times 6$ .
3. *Megascolides intermedius*. The spermiducal glands lie in segment 18, transversely to the body. On the ventral surface is seen the mass of unicellular glands, the surface being mottled with patches of pigment. The nerve-cord runs above this.  $\times 6$ .
4. *Megascolides victoriæ*. Spermiducal gland of right side lying in segments 18 to 29. The duct is much coiled.  $\times 6$ .
5. *Megascolides roseus*. Spermiducal gland of left side. Gland very much coiled.  $\times 6$ .
6. *Diplotrrema fragilis*. Spermiducal glands and ventral accessory glands.  $\times 18$ .
7. *Acanthodrilus sydneyensis*. Two pairs of spermiducal glands. The position and opening of the vas deferens on segment 18 is shown by a dotted line.
8. *Megascolex Frenchi*. Lobate spermiducal gland of right side, in segments 18 and 19. The markings on the surface of the gland may be clearly seen.  $\times 6$ .
9. *Megascolex Dendyi*. Spermiducal gland of right side. Lobate in segments 18 and 19, with a curved duct in segment 18.  $\times 6$ .
10. *Megascolex dorsalis*. Spermiducal gland of left side. Surface showing irregular markings. Duct very short.  $\times 6$ .
11. *Digaster queenslandica*. Gland of right side. Surface-markings slightly visible. No duct to be seen from above.  $\times 6$ .
12. *Digaster queenslandica*. Spermiducal gland of another individual. Tubular in appearance. No duct visible.  $\times 12$ .
13. *Digaster armifera*. Trilobed gland of right side with setal sacs and muscles belonging to them, attached to the terminal part of the gland-duct.  $\times 6$ .
14. *Megascolex Fielderi*. Bilobed gland of left side with lobular surface-markings. Duct curved and entering muscular bulbus.  $\times 6$ .
15. *Megascolex intermedius*. Portion of section showing sperm-reservoir of right side with its division into two parts, the lower containing the sperm-rosettes, and developing sperm in both. The vas deferens from the previous segment may also be seen, and the nerve-cord in position. Zeiss A.A. oc. (2).
16. *Megascolides insularis*. Transverse section of spermiducal gland showing ordinary gland-cells, special club-shaped cells, and columnar lining. The whole enclosed in peritoneum. Zeiss D. oc. (2).

## PLATE 15.

Fig. 17. *Megascolides intermedius*. Transverse section through gland-wall, showing groups of gland-cells. The outlines of the columnar cells lining the duct are not visible. The nuclei are clearly seen, as also

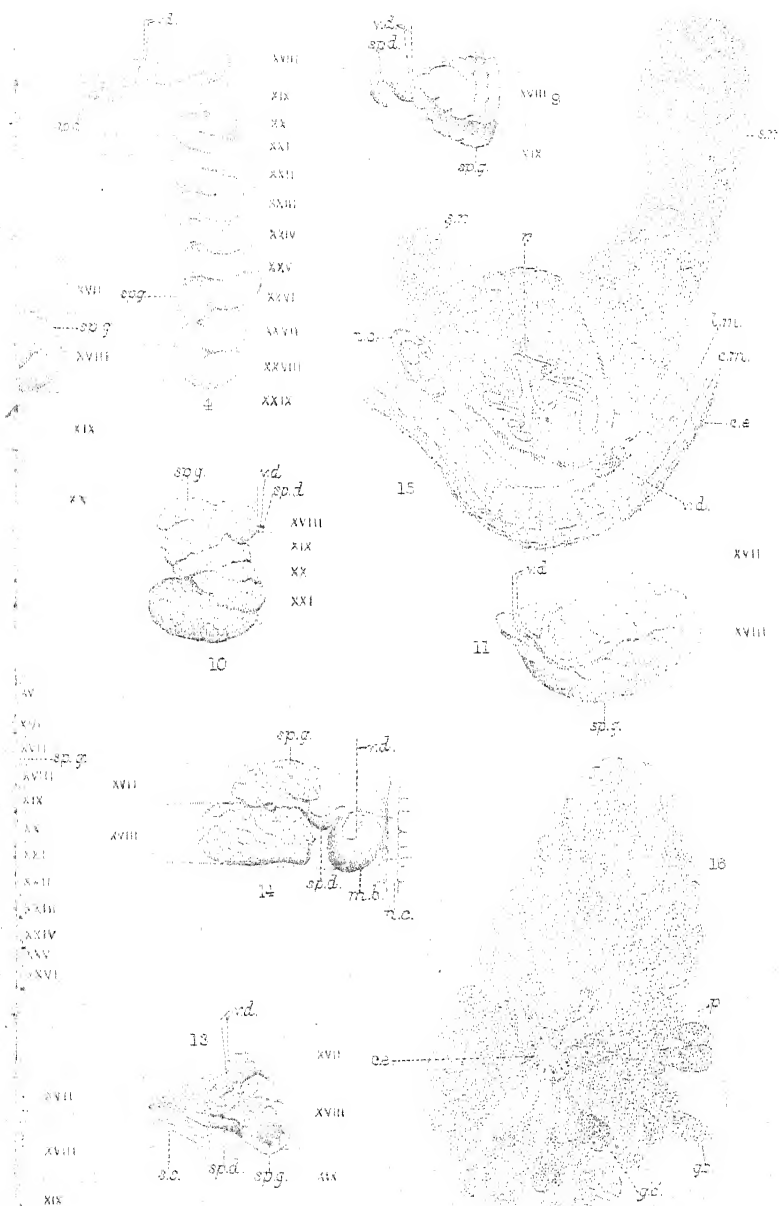


Sweet.



G Sweet del.  
A.R. Hammond lith.

SPERMIDUCAL GLAN



West, Newman trip.

Sweet



G Sweet del.  
A R. Hammond lith.

SPERMIDUCAL GLAND





the horny layer next the lumen. Two small blood-vessels are seen running in from the surface. Zeiss D. oc. (2).

Fig. 18 a. *Acanthodrilus sydneyensis*. Transverse section through duct of gland showing nuclei of columnar lining and the circular muscle-layer.

18 b. *Acanthodrilus sydneyensis*. Transverse section through the intermediate part of gland showing nuclei of columnar cells surrounded by short granular cells.

18 c. *Acanthodrilus sydneyensis*. Oblique section through terminal glandular part of gland. A blood-vessel is seen running up one side. The irregular gland-cells are shown; the relative depth to which they are stained with methylen-blue is shown by the shading. Zeiss D. oc. (2).

19. *Digaster brunneus*. Section across lobate gland showing the granular gland-cells and the apparently empty cells all with their ducts opening into a very small central space without any lining membrane. Around the lobule are a number of blood-vessels separating it from its neighbours. Zeiss E. oc. (2).

20. *Megascolex tasmanica*. Section across lobule in gland showing the gland-cells opening into a much larger lacuna, which is connected with one of the five terminations of the gland-duct by means of a branch with a single layer of much flattened epithelium cells. The cut ends of some of the glandular cell-ducts are seen in the lacuna. No blood-vessels were visible, and are probably present in the form of sinuses. Zeiss E. oc. (2).

21. *Megascolides intermedius*. Portion of transverse section through region of the spermiducal gland showing portion of wall of spermiducal duct cut through, and the mass of unicellular glands occupying the ventral surface here, with their ducts opening to the surface. The position of the nerve-cord is shown and the muscular layers of the body-wall. Zeiss C. oc. (2).

22. *Diploptrema fragilis*. Portion of transverse section showing the relations of the spermiducal duct, accessory glands, setæ and setal sacs, and nerve-cord. The vas deferens has opened two sections anterior to this, while the spermiducal gland opens two or three posterior to this. The opening of one group of gland-cells is seen cut through at a'. Zeiss A. oc. (2).

23. *Megascolex dorsalis*. Transverse section of the accessory glands (a.g. and a.g.') surrounding the opening of the spermiducal gland which is seen cut through obliquely. The groups of unicellular ducts are clearly seen in the lower portion of the section. Zeiss C. oc. (2).

24. *Cryptodrilus illawarrae*. Portion of transverse section showing the lower part of the gland, the gland-duct, vas deferens, and the two setæ in their sacs. Zeiss A. oc. (2).



The Subterranean Amphipoda of the British Isles. By CHARLES CHILTON, M.A., D.Sc., F.L.S., Research Fellow, University of Edinburgh.

[Read 21st June, 1900.]

(PLATES 16-18.)

ALTHOUGH the first subterranean Amphipod that was definitely recognized and described as such was a British species, and although the different species known at the time were described and figured in some detail by Spence Bate and Westwood in 1863 [1. pp. 311 to 328] \*, very little has been published on the group by subsequent British writers, though on the Continent several important papers dealing with the subject have appeared. These Amphipods are known to be widely distributed in the southern parts of England and they have been also recorded from Dublin, and, judging from experience in other countries, they are probably fairly abundant; but at the same time it is by no means easy to obtain specimens, for they are either altogether overlooked by the ordinary householder, or, if they are seen, their presence is, as Mr. Stebbing [2. p. 30] has pointed out, kept a secret from the fear that the well may otherwise be closed by the sanitary authorities. There are several points that are still uncertain with regard to the number and distribution of the British species, and in the course of a wider study of subterranean Crustacea I was anxious to solve these so far as possible, and to attract fresh attention to the subject in the hope that further knowledge might be obtained upon it. This paper is the result of the work that I have been able to do on the subject; but though various friends have generously supplied me with all their available material, I regret that the results must seem somewhat meagre, and that I am not able to add very much to the information given many years ago by Spence Bate. However, I give fuller details of some of the species and revise the nomenclature, after comparison with some of the European species. I also give a very short sketch of the growth of our knowledge on the subject, and some brief notes on the distribution of the British species.

\* The numbers in square brackets refer to the list of references at the end of the paper.

For supplying me with material I desire to record my best thanks to the Rev. T. R. R. Stebbing, who has very kindly placed the whole of his specimens of the group at my disposal, to Professor D'Arcy W. Thompson, C.B., of University College, Dundee, to Dr. R. T. Scharff of Dublin, and to Dr. S. F. Harmer of Cambridge. Monsieur Edouard Chevreux of Bône, Algeria, and Professor Franz Vejdovsky of Prague have given me specimens from some localities on the Continent that have been most useful for the purpose of comparison.

### *Historical.*

The first mention of subterranean Crustacea in the British Isles was made by Leach [3. p. 403] in the article "Crustaceology" in the 'Edinburgh Encyclopædia,' published probably in 1813 or 1814. His specimen came from a well in London, and was by him distinguished from *Gammarus pulex* under the name *G. subterraneus*. His description is very brief and insufficient, but from what he says it is, I think, evident that the specimen must have belonged to the genus now known as *Niphargus*; and from our present knowledge of the distribution and occurrence of the species of this genus, it is perhaps not unreasonable to suppose that it was the species which is most commonly found and which has long been known in England by the name *Niphargus aquilex*, Schiödte, and I have accordingly in this paper followed Della Valle in adopting Leach's name for this species. Spence Bate and Westwood give Leach's species as a synonym of *N. aquilex*, though retaining the later name of the species [1. p. 314].

For many years nothing appeared on the subject in England, though on the Continent species of subterranean Amphipods were described by Gervais [4. p. 127], Koch [5], Schiödte [8], Caspary [6], Hosius [7], &c., and in 1851 the genus *Niphargus* was established by Schiödte.

In 1853 a subterranean Amphipod was found by J. O. Westwood at Maidenhead [9. p. 218]; this was at first referred to *N. stygius*, Schiödte, but was shortly afterwards described as a separate species, *N. aquilex*, by Schiödte. This species was accepted as a good one by Spence Bate and Westwood, though on different grounds from those relied upon by Schiödte in defining the species. Adam White, in his 'Popular History

of the British Crustacea' [10], gave the species under the name *Niphargus aquilex*, Schiödte, and suggested that it was the same as *Gammarus subterraneus*, Leach. Some account of it was given anonymously in the 'Natural History Review' in 1857.

In 1859 Spence Bate [11] described two new species of *Niphargus*, viz. *N. fontanus* and *N. Kochianus*, and also established the new genus *Orangonyx* for another species, *O. subterraneus*, found by the Rev. H. R. Hogan at Ringwood. In the same year Hogan gave some account of the habits, food-supply, &c. of these three species [12. pp. 166-169].

All the British subterranean species were given by Spence Bate in the 'Catalogue of the Amphipoda in the British Museum' in 1862 [13. pp. 174 &c.], and afterwards by Bate & Westwood in their 'History of the British Sessile-eyed Crustacea,' where full descriptions are given and some general remarks are made on their affinities, habits, distribution, &c. [1. pp. 311 to 328].

I do not know of any further work in English specially dealing with these Crustacea, though naturally they have frequently been referred to in some of the numerous works dealing with the similar forms found in other countries; some remarks upon them are made too by Stebbing in the course of the Bibliographical Introduction to his "Report on the 'Challenger' Amphipoda."

Quite recently a species of *Niphargus* has been recorded from Cringleford, near Norwich, by Dr. S. F. Harmer [14. pp. 489-491]; and the Rev. T. R. R. Stebbing [2] has drawn attention to the whole subject of the British subterranean fauna in his address to the Associated Societies at the Dover Meeting of the British Association.

Of the writers on European species it will be sufficient to mention the names of Valette St. George [15]; Joseph [16]; de Rougemont [17], whose papers led to so much controversy; Humbert [18], who described a variety of *Niphargus puteanus*, Koch, with an accuracy and fullness of detail that has scarcely been equalled since; Moniez [19]; and Wrześniowski [20], in whose paper a full historical account of the subject will be found.

More recently Chevreux [22] has described a new species of *Niphargus* from France, Vejdovsky has published valuable papers

on *Crangonyx* [21] and on the rudimentary eyes of *Niphargus* [34], and Armand Viré [23] deals with two species of the latter genus in his work 'La Faune souterraine de France,' issued during the present year.

In North America several similar Amphipods have been discovered and have been described by Cope [24], Packard [25], Forbes [27], Benedict [26], &c.; full information of the cave-fauna of North America will be found in Packard's larger memoir published in 1888, and he has rediscussed some of the theoretical bearings of the facts in a subsequent paper [35].

The New-Zealand forms first recorded by me in 1881 and 1882 are fully described in my paper in the 'Transactions of the Linnean Society' in 1894 [28. pp. 163-284]. Closely allied Amphipods, but with normal eyes, were described from Tasmania by G. M. Thomson in 1892 [29]; and within the last year a blind species of *Niphargus* has been found by O. A. Sayce in Gippsland, Victoria, Australia [30. pp. 152-159].

#### *Distribution of the British Species.*

Owing to the isolated localities in which they are found and to the fact that specimens have fallen into the hands of many different observers, a large number of species of *Niphargus* has already been described, some of them probably on insufficient grounds. In his revision of the genus in 1890 Wrześniowski gives a list of 14 species, six, however, he marks as doubtful; and Stebbing [31. p. 425] has since suggested that one of these, *Niphargus Moniezi*, may perhaps more appropriately find a place under *Neoniphargus*. On the other hand, Chevreux has recently described a new species, *N. Virei*, from the grottos of the Jura and tells me by letter that he has other new species to describe. Other writers, such as de Rougemont and Della Valle, again, have supposed that the different species described are merely forms of one wide-spread species, and have caused great confusion by reducing them all to synonyms of *Niphargus puteanus*, Koch. The latest effort of this kind is that of Hamann [33. p. 234], who recognizes neither *Niphargus* nor *Crangonyx*, and classes all the subterranean Amphipods of Europe under *Gammarus puteanus*, Koch. It is almost incredible that he should come to this conclusion after avowedly studying Wrześniowski's work, and it will be evident to all that he has quite failed to appreciate

the careful observations of the latter, and his view that *all* the recorded species are forms of one cannot be for a moment accepted.

Fortunately there is no great difficulty in identifying our British species. Besides *Niphargus fontanus*, which I have not seen, we have three species. The first, *N. subterraneus*, Leach, is known from many districts in the Southern Counties of England and as far north as Norwich; it has not been recorded from Scotland nor Ireland; Mr. Thomas Scott tells me that he has frequently sought for subterranean crustaceans from wells near Edinburgh without success, and I have not been able to hear of them in any part of Scotland, though I have made frequent inquiries; neither could it be found in the Irish caves investigated by Carpenter and others, though it had been specially looked for years before by Wright and Halliday [36. p. 26]. In Europe the species is very widely distributed and has been recorded from many localities in France, Austria, Bohemia, Germany, Poland, &c.

The second species, *N. Kochianus*, Spence Bate, has been recorded from several localities in the South of England, and is also found in Ireland at Dublin. In Europe it is so far known from Munich only, though it is doubtless to be found at other places; and it seems probable that *N. puteanus*, described by Hosi-us from Bonn, is the same species.

The third species, *Orangonyx subterraneus*, Spence Bate, is known in England only from Ringwood and Marlborough and appears to be rare, for in each case only a single specimen was obtained. In Europe a few specimens have been recorded from Radotin near Prague by Vejdovsky, and many years previously it was taken at Munich by de Rougemont.

From this it appears that, with the exception of *N. fontanus*, which is as yet known only from Spence Bate's description, all the British forms belong to species widely distributed in Europe.

#### Genus NIPHARGUS, Schiödte.

1851. *Niphargus*, Schiödte, Det danske Videnskabernes-Selskabs Skrifter, 5e Raekke. Naturvidenskabelig og Mathematisk Afdeling, Bd. ii. p. 26.

The genus *Niphargus* was established by Schiödte in 1851 for the reception of some subterranean Amphipoda and was accepted

by Spence Bate & Westwood, who gave a fuller diagnosis in 1863 [1. p. 311]; in 1876 Humbert gave a still fuller description [18. p. 312]; and more recently Wrześniowski [20. p. 620] has given a full critical history and account of the genus, followed by a Latin diagnosis, of which I give a translation here:—

“Eyes none (or rudimentary).

“Body compressed, not carinate. Fourth and fifth segments of the pleon bearing slender setules. Epimera small.

“Superior antennæ longer than the inferior, with a secondary appendage of not more than two joints; primary flagellum bearing olfactory setæ and hyaline bacilli. Flagellum of inferior antennæ in both sexes bearing only hyaline bacilli.

“Gnathopoda similar, subchelate, with the penultimate joint (propodos) dilated, of nearly the same form in both sexes.

“Terminal uropoda biramous, inner ramus very small, outer ramus elongate, two-jointed (or one-jointed?).

“Telson more or less deeply cleft.

“Molar tubercle of the mandibles supplied with a long seta; palp narrow, three-jointed.

“First maxillæ furnished with forked spines; palp large, two-jointed, of the same form in the right and left maxillæ, armed at the apex with spines and setæ; inner lobe narrow, bearing only two or three setæ at the apex.

“Second maxilla with the inner lobe bearing setæ at the apex only.

“Outer lobe of the maxillipedes armed on its inner margin with teeth, at the apex with teeth and strong setæ; inner lobe armed at the apex with three strong teeth and a very few setæ, the inner margin destitute of setæ; palp elongate, the last joint very narrow towards the apex, unguiform.”

This is rather a long and unwieldy generic description, and no doubt the diagnosis could be considerably curtailed if *Niphargus* were compared with allied genera and the characters common to several genera carefully eliminated; and this will I hope be done by the Rev. T. R. R. Stebbing in his account of the Amphipoda prepared for ‘Das Tierreich.’ In his paper on new genera of the Gammaridæ already published [31] he does not give revised diagnoses of the genera previously known, but among the new genera he gives one, *Neoniphargus*, which appears to come very close to *Niphargus*, the only important difference being that in

it the third uropoda are not elongate and their outer branch consists of one joint only.

The affinities of *Niphargus* were fully discussed by Wrześniowski in 1890, and in the present state of our knowledge it does not appear possible to add very much to what he then said. Its nearest allies seem to be the *Neoniphargus* already mentioned and *Crangonyx*, with the genera *Paracrangonyx* and *Eucrangonyx* lately established by Stebbing, while the little-known marine genus *Eriopsis* also seems to be nearly related. Naturally enough it has frequently been compared with *Gammarus*, since freshwater species of this genus are often present in the districts where the subterranean *Niphargi* are found. Wrześniowski has pointed out that most of the external characters of *Niphargus* are shared by various species of *Gammarus*, and that consequently these alone are not sufficient to distinguish the two genera; he has, however, shown that there are important differences in the mouth-parts, and these he has described in great detail. Although there are considerable differences between the mouth-parts of a typical *Gammarus* and a typical *Niphargus*, there are already known some intermediate species, and no doubt others will hereafter be described which will still further bridge over the gap between the two. Some of the numerous species from Lake Baikal referred to *Gammarus* by Dybowsky present external resemblances to *Niphargus*; but although many of them have been assigned to new genera by Stebbing, no satisfactory account of their mouth-parts has as yet been published, and without this it would be useless to attempt any detailed comparison. In his account of the genus *Crangonyx* Professor Vejdovsky has drawn special attention to the sensory setæ found on various parts of the body and appendages; and he tells me that in these and also in some parts of the internal anatomy, especially in connection with the renal gland in the base of the lower antennæ, he has found good points of difference not only between allied genera such as *Gammarus*, *Niphargus*, and *Crangonyx*, but in some cases even between different species of the same genus—a paper dealing with these points will shortly be published by him. It is unfortunate that most of these characters, important as they are, can be observed only in fresh specimens or require to be elucidated by the cutting of serial sections, and that consequently they have been and, to a large extent, probably will continue to be neglected by the systematist.

- NIPHARGUS SUBTERRANEUS, *Leach*. (Plates 16 and 17. fig. 1.)
1814. *Gammarus subterraneus*, Leach, Edinburgh Encyclopædia, vol. vii. p. 403.
- 1841-4. *Gammarus puteanus*, Koch, Deutschlands Crustaceen, Myriapoden und Arachniden, Heft 36, Taf. xxii.
1853. *Niphargus stygius*, Westwood, Proc. Linn. Soc., No. li. p. 218.
- "      "      Spence Bate, Ann. & Mag. N. H. ser. 2, xix. p. 146.
1855. *Niphargus aquilex*, Schiödte, Oversigt over det Kg. Danske Vidensk.-Selskabs Forhandling, 1855, pp. 349-351; also in Nat. Hist. Review, i. p. 41, fig. B.
1857. *Niphargus aquilex*, White, Popular History of British Crustacea, p. 187.
1857. *Gammarus puteanus*, La Valette St. George, "De Gammaro puteano," Dissertatio Inauguralis, 1857.
1862. *Niphargus stygius*, Spence Bate, Cat. Amphip. Brit. Mus. p. 174, pl. xxxii. fig. 1.
1863. *Niphargus aquilex*, Spence Bate & Westwood, Brit. Sessile-eyed Crust. i. p. 315.
1888. *Niphargus aquilex*, Stebbing, Report on the 'Challenger' Amphipoda, p. 316.
1889. *Gammarus puteanus* ("à main triangulaire"), Moniez, Rev. Biol. du Nord de la France, i. pp. 41-46.
1890. *Niphargus puteanus*, Wrześniowski, Zeitschrift für wissenschaftliche Zoologie, L. 4, p. 673.
1893. *Niphargus subterraneus*, Della Valle, Gammarini del Golfo di Napoli, p. 704 (*in part*).
1896. *Gammarus puteanus*, Hamann, Europäische Höhlenfauna, Jena, p. 234 (*in part*).
1899. *Niphargus aquilex*, Harmer, Trans. Norfolk & Norwich Naturalists' Society, vol. vi. pp. 489-491.
1900. *Niphargus puteanus*, Armand Viré, Faune souterraine de France, p. 34 &c.

*Specific diagnosis*.—Body slender, first four side-plates not so deep as their respective segments; postero-inferior angles of the first three segments of the pleon broadly rounded.

Superior antennæ half as long as the body; flagellum of about 20 joints, rather more than one and a half times the length of the peduncle; secondary appendage of two joints, shorter than the first two joints of the main flagellum. Inferior antenna with the flagellum of 7 to 9 joints.

Maxillipedes with the lobes small, inner lobe reaching only to the end of the inner margin of the meros, and outer lobe reaching only halfway along the inner margin of the carpus.



First gnathopod with the basos very broad, the width at the distal end in the male being fully one-half the length: ischium and meros both short and subquadrate and of about equal size; meros with its distal border fringed with a row of long setæ, of which one is much longer than the others and is finely barbed, curved, and reaches about as far as the end of the propodos; greatest length of the carpus considerably less than that of the propodos; extremity very oblique and nearly all occupied by the articulation of the propodos, so that the posterior border is very short; a tuft of setæ at the antero-distal angle, and a row along the outer edge of the short posterior border, on the inner surface is a row of about seven long setæ along the half of the oblique extremity nearest to the posterior border: propodos large, subtriangular, broadest distally where the breadth is slightly greater than the length of the anterior border: palm transverse, straight or slightly convex; anterior border with a tuft of about six setæ at base of dactylos, and a smaller tuft situated a little proximally to this; the posterior border bears six short transverse rows of setæ; palm defined by a stout spine, and near it two smaller spines coarsely serrated, along the palm is a row of short setæ, with one or two longer ones at intervals: dactylos fitting closely on to the palm, terminal claw very acute, secondary claw distinct and sharp with a short seta at its base, outer border convex and bearing only one seta opposite the base of the secondary claw.

Second gnathopod slightly larger than the first, but very similar in form: basos not so broad, the greatest breadth being rather less than half the length; ischium and meros similar to those of the first gnathopod, but the meros without the large curved seta; carpus as long as the propodos, rather more slender than in the first gnathopod, the posterior surface longer and slightly concave for the reception of the base of the propodos, both edges bearing a row of setæ; propodos as in the first gnathopod, but with the breadth at distal end distinctly greater than the length of the anterior border; posterior border very convex and with nine rows of setæ; dactylos as in first gnathopod.

First and second pereiopoda equal in length, third slightly longer, fourth and fifth each distinctly longer than the one immediately preceding. Basa of third, fourth, and fifth pereiopoda rather narrow, the greatest breadth being rather more than one-half of the length.

Terminal uropoda in the fully-grown male nearly one-half the length of the body; outer ramus of two subequal joints, the first with four tufts of setæ, the terminal one nearly free from setæ, except a small tuft at the apex. In the female the terminal uropoda one-fourth the length of the body, and the last joint of outer ramus only about one-third of the first.

Telson reaching to the end of the peduncle of the third uropoda, split to more than half its length, each lobe narrowing towards the apex, which bears three stout setæ; outer margin convex, and with two fine setæ a little anterior to the apex.

Length of fully-grown specimens about 11 mm.

*Habitat.* Southern Counties of England; (Europe generally).

The above description will, I hope, be sufficient for the identification of this species. A much more detailed description is given by Humbert of *Niphargus puteanus* var. *Forelii*, from Lake Geneva. Wrześniowski indeed thinks this form sufficiently distinct to rank as a separate species, *N. Forelii*; but though he is perhaps right, the differences are very slight. Wrześniowski's full description of *Niphargus puteanus* var. *Vejdovskyi* may also be consulted.

The points chiefly relied upon by Wrześniowski for the separation of the different species of *Niphargus* are the lengths of the antennæ and terminal uropoda in proportion to the body, the depth of the side-plates, the relative lengths of the pereopoda, the shape of the propoda of the gnathopoda and of the lower margins and angles of the first three segments of the pleon, and the relative lengths of the two joints of the outer ramus of the third uropod. These points he found to be fairly constant in specimens of different ages from the same locality; and they no doubt are good specific characters, though it is a little difficult to estimate some of them with accuracy, and I am inclined to think that Wrześniowski relied a little too much on the supposed accuracy of the descriptions and figures given by other writers. It must be remembered, too, that the relative lengths of the two joints of the outer ramus of third uropoda varies in the two sexes.

In addition to these points, I have found the shape of the maxillipedes and of the more proximal joints of the gnathopoda, especially the basos and the carpus, useful points for distinguishing the British species; while the number of setæ arising from the outer margin of the dactylos is a character that may be useful for readily separating some species, such as *N. tatrensis*,

Wrześniowski. The slight differences of the two gnathopoda in the form of the carpus have hitherto received little attention.

I do not propose to enter into any points of internal anatomy, but, as the question of the degree of the degeneration of the eyes is of special interest, I may call attention to a recent paper by Vejdovsky, in which he criticises the accounts previously given, and, after a careful examination by means of serial sections, comes to the conclusion that in none of the species specially dealt with is there any organ present corresponding to a normal Arthropodan eye; and that only in *N. puteanus*, Koch, is it possible to speak of a true eye-rudiment, and that even here the degeneration has gone so far that the cells of the "Augen-anlage" have been modified into a tendon-like bundle that serves to attach the large brain-ganglia to the walls of the head [34. p. 10].

The chief points by which the present species differs from other species of the genus appear to be:—

The body is slender.

The four anterior side-plates are not so deep as their segments.

The upper antennæ are not more than half the body-length.

The gnathopoda have the basos broad, the carpus not longer than the propodos, the propodos rather broader than long, the dactylos with only one seta on its convex margin and only three or four very small ones on the concave margin.

The first three segments of the pleon have the postero-inferior angle broadly rounded.

The outer branch of the third uropod has the two joints of nearly the same length in the male, and in fully-grown specimens the last joint bears only few very short setæ. (In younger males the terminal joint, though of about the same length as the first, may be more abundantly supplied with setæ, and these may be longer than is shown in Plate 16. *ur. ♂*.)

*NIPHARGUS KOCHIANUS*, *Spence Bate*. (Plates 16 and 17. figs. 2 & 3.)

1859. *Niphargus Kochianus*, Spence Bate, Proc. Dublin Univ. Zool. & Bot. Assoc. i. p. 239, figs. 1 and 1a; Nat. Hist. Rev. vol. vi. p. 165, fig. 1.

1859. *Niphargus Kochianus*, Hogan, Nat. Hist. Rev. vol. vi. pp. 166-169.

1861. *Niphargus Kochianus*, Hogan, Rep. Brit. Assoc. (1860) pp. 116-117.

1862. *Niphargus Kochianus*, Spence Bate, Cat. Amphip. Brit. Mus. p. 177, pl. xxxii. fig. 3.  
1863. *Niphargus Kochianus*, Spence Bate & Westwood, Brit. Sessile-eyed Crust. i. p. 323.  
1889. *Gammarus Kochianus*, Moniez, Rev. Biol. du Nord de la France, i. p. 48.  
1890. *Niphargus Kochianus*, Wrześniowski, Zeitschrift für wissenschaftliche Zoologie, L. 4, p. 674.  
1893. *Niphargus Kochianus*, Della Valle, Gammarini del Golfo di Napoli, p. 704 (*in part*).  
1896. *Gammarus puteanus*, Hamann, Europäische Höhlenfauna, p. 234 (*in part*).

*Specific diagnosis*.—Body less slender than in *N. subterraneus*, first four side-plates as deep as their segments.

Second and third segments of pleon with posterior angles acute, that of the first rectangular.

Superior antenna about two-thirds the length of the body, slender; third joint of peduncle more than half as long as the preceding joint; flagellum containing about 16 joints, secondary appendage of two slender joints, as long as the first two joints of the main flagellum.

Inferior antenna with the last two joints of peduncle equal, rather slender; flagellum of about 8 joints, half as long again as the last joint of peduncle.

Maxillipedes with the lobes large, inner lobe reaching considerably beyond the distal end of the inner margin of the meros, and the outer lobe reaching as far as the end of the carpus.

First gnathopod shorter and rather stouter than the second; basos not specially broadened; carpus as long or longer than the propodos; propodos subquadrate, widest distally where the width is rather greater than the length; palm transverse, produced anteriorly as it approaches the inferior angle, so that this is rather less than a right angle, defined by a stout spine with a smaller one at its base; dactylos fitting closely on to the palm, convex border with only one or two setæ.

Second gnathopod slender; carpus much longer than propodos, its inferior margin not much shorter than the anterior, and supplied with five tufts of setæ; propodos as in first gnathopod, but narrower, its articulation with the carpus very narrow.

Terminal uropoda about one-fifth of the length of the body; outer branch with the first joint about four or five times as long as the peduncle, and supplied with three or four tufts of setæ;

second joint slender, one-fourth as long as the first, with a single seta at the apex.

Telson cleft for three-fourths of its length; lobes widely separated, their outer border nearly straight, with one long plumed seta, and a smaller one one-fourth from the apex, inner border slightly convex, extremity with four stout setæ.

Length about 5 mm.

*Habitat.* Ringwood, Hants; Warminster and Marlborough, Wilts; and Dublin. (In Europe recorded from Munich.)

This species appears to be less common than the preceding, and has consequently received less attention.

I have specimens from Marlborough and from Dublin, and have also been able to examine specimens from Munich; and though there are a few small differences that could easily be pointed out, I think these all belong to the one species. I feel pretty certain that *N. puteanus*, Hosius, from Bonn belongs to this species, and it seems not unlikely that *N. puteanus*, Koch, from Regensburg, also belongs to the same species. However this may be, it appears clear that the present species is quite a different form from *N. subterraneus*, and that it is widely distributed in Europe and the British Isles. The points by which it may be distinguished have mostly been mentioned in the brief description already given. Perhaps the most characteristic points are to be found in the gnathopoda, which have the carpus much longer in proportion to the other joints, and have the propodos articulated to it only at the distal end and lying in the same straight line as the carpus; while in *N. subterraneus* the propodos usually lies nearly at right angles to the carpus, and its articulation with it is consequently oblique and occupies part of the short inferior margin. The propodos itself is not so broad as in *N. subterraneus*, and has the inferior angle of the palm produced in a very characteristic manner, especially in the first gnathopod. The amount of this projection varies a little in different specimens, as may be seen from a comparison of figs. 2 *gn.*<sup>1</sup>, *gn.*<sup>2</sup>, and 3 *gn.*<sup>1</sup>, *gn.*<sup>2</sup>, and it appears to be greater in small specimens. Fig. 2 *gn.*<sup>1</sup> shows the propodos of the first gnathopod of a small specimen (4 mm. long) from Dublin, and in this the projection is very marked so that the gnathopod might almost be called imperfectly "chelate" instead of "subchelate," the inferior margin bears only two distinct transverse rows of setæ, though the third and most proximal one is represented by a single seta. The

portion of the propodos bordering the palm and its inferior angle differs from the rest of the joint in presenting a peculiar stippled and striated appearance; and it is evidently this that is represented by the shading in Spence Bate's figure in the 'Hist. Brit. Sessile-eyed Crustacea,' p. 323. This "marginate" appearance is not so marked in the larger specimen from Marlborough (see figs. 3, *gn.*<sup>1</sup>, *gn.*<sup>2</sup>), nor in the specimens from Munich, and the tufts of setæ on the inferior margin of the propodos are more numerous. The first gnathopod is considerably shorter and rather stouter than the second; and may also be distinguished from it by the long curved seta on the meros, which is present just in the same position as in *N. subterraneus*, in which species the two gnathopoda are not so easily distinguished.

The large size of the inner and outer lobes of the maxillipedes is another point that readily separates this species from *N. subterraneus*.

The terminal uropoda do not appear to become so elongate as in *N. subterraneus*, but the specimens at my disposal are not sufficient to enable me to say how far they differ in the two sexes.

*NIPHARGUS FONTANUS*, Spence Bate.

1859. *Niphargus fontanus*, Spence Bate, Proc. Dublin Univ. Zool. & Bot. Assoc. i. p. 233, figs. 2 & 2a; Nat. Hist. Rev. & Quarterly Journal of Science, vol. vi. p. 165, fig. 2.  
*Niphargus fontanus*, Hogan, Proc. Dublin Univ. Zool. & Bot. Assoc. i. p. 240; Nat. Hist. Review, vol. vi. p. 166.
1862. *Niphargus fontanus*, Spence Bate, Cat. Amphip. Brit. Mus. p. 175, pl. xxxii. fig. 2.
1863. *Niphargus fontanus*, Spence Bate & Westwood, Brit. Sessile-eyed Crust. i. p. 319.
1889. *Gammarus fontanus*, Moniez, Rev. Biol. du Nord de la France, i. p. 48.
1890. *Niphargus fontanus*, Wrzesniowski, Zeitschrift für wissenschaftliche Zoologie, L. 4, p. 674.
1893. *Niphargus puteanus*, Della Valle, Gammarini del Golfo di Napoli, p. 704 (*in part*).
1896. *Gammarus puteanus*, Hamann, Europäische Höhlenfauna, p. 234 (*in part*).
1896. *Niphargus fontanus*, Walker & Hornell, Jour. Mar. Zool. & Micros. vol. ii. p. 54.

Bate and Westwood describe this species as follows:—

"Moderately robust. Coxæ of the first four pairs of legs  
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nearly as deep as the segments to which they are attached. Gnathopoda having the propoda pear-shaped, with the palm oblique, and as long as the superior margin, which is nearly straight; inferior margin convex and posteriorly produced; palm defined by one or two movable spines. Anterior segments of the tail with the posterior angles pointed. Length  $\frac{1}{2}$  inch."

I have not yet been able to examine a specimen of this species, though Bate and Westwood record it from Ringwood in Hants, Corsham in Wiltshire, and High Elms in Kent. It appears to be readily distinguished from the other British species by the pear-shaped propoda of the gnathopods and by the oblique palm. It is given by Wrześniowski as a good species.

Specimens identified by Messrs. Hornell and Sinel as *N. fontanus* have been found in two wells on the outskirts of St. Helier, Jersey, and are mentioned by Messrs. Walker and Hornell in their report on the Schizopoda &c. of the Channel Islands. I have endeavoured to trace these specimens or to obtain others from the same locality, but without success, although Mr. Hornell used his best efforts on my behalf.

#### Genus CRANGONYX, Spence Bate.

*Crangonyx*, Spence Bate, Proceed. Dublin Univ. Zool. & Bot. Assoc. 1859, p. 240; Nat. Hist. Review & Quarterly Journal of Science, vi. p. 165; Cat. Amph. Crust. Brit. Mus. p. 178: Bate & Westwood, Hist. Brit. Sessile-eyed Crust. i. p. 326: Della Valle, Gammardini del Golfo di Napoli, p. 681: Vejdovsky, Sitzungsberichte der Königl.-böhmischen Gesellschaft der Wissenschaften Prag Mathematisch-naturwissenschaftliche Classe, 1896, x. p. 5.

I have given above only the most important references bearing on this genus; a full historical account of it will be found in the one last given. Vejdovsky, however, has not given an amended diagnosis of the genus, and in order to avoid confusion, I shall not attempt to do so either, as that will, I presume, be done by Mr. Stebbing in his forthcoming account of the Amphipoda for 'Das Tierreich.'

It is closely allied to the genera *Paracrangonyx* and *Eucrangonyx* recently established by Mr. Stebbing. *Boruta*, Wrześniowski, is also very nearly allied to *Crangonyx*, and is indeed considered by Vejdovsky to be identical with it; while *Goplana*, Wrześniowski, is considered by him as merely a subgenus of *Crangonyx*, and the species *Goplana polonica* as a surface-species repre-

senting the form from which the subterranean species of *Crangonyx* in Europe is probably derived. Nearly allied species are found in the surface and underground waters of North America, and were formerly assigned to the genus *Crangonyx*, though most of them have now been placed in new genera by Mr. Stebbing.

CRANGONYX SUBTERRANEUS, *Spence Bate*. (Plate 18. figs. 4.)

1859. *Crangonyx subterraneus*, Spence Bate, Proc. Dublin Univ. Zool. & Bot. Assoc. i. p. 240; Nat. Hist. Rev. vol. vi. p. 166, fig. 3.  
 1861. *Crangonyx subterraneus*, Hogan, Rep. British Assoc. (1860), pp. 166-169.  
 1862. *Crangonyx subterraneus*, Spence Bate, Cat. Amphip. Brit. Mus. p. 178, pl. xxxii. fig. 6.  
 1863. *Crangonyx subterraneus*, Spence Bate & Westwood, Brit. Sessile-eyed Crust. i. p. 327.  
 1890. *Crangonyx subterraneus*, Wrzesniowski, Zeitschrift für wissenschaftliche Zoologie, L. 4, p. 697.  
 1893. *Crangonyx subterraneus*, Della Valle, Gammarini del Golfo di Napoli, p. 681.  
 1896. *Crangonyx subterraneus*, Vejdovsky, Sitz. kgl.-böhm. Gesellschaft der Wissenschaften, 1896, x. pp. 3-32, pls. i. & ii.  
 1896. *Gammarus puteanus*, Hamann, Europäische Höhlenfauna, p. 234, (in part).  
 1899. *Eucrangonyx Vejdovskyi*, Stebbing, Trans. Linn. Soc., Zoology, ser. 2, vii. p. 423.

*Specific diagnosis*.—First four side-plates nearly as deep as their respective segments, the fourth much the largest, being about twice as long as the third; the lower margins of all convex and supplied with a few setæ.

Superior antennæ about one-fourth the length of the body; the flagellum of about 12 joints; secondary appendage of two slender joints, the first much longer than the second.

Inferior antennæ with the flagellum of 4 joints, the articulations between them slightly oblique.

Mandible with the palp rather broad, its second joint half as broad as long, its inner margin being produced and convex.

First gnathopod rather shorter than the second, carpus subtriangular, much shorter than the propodos: the propodos subquadrate, length of anterior border one and a half times the breadth; palm oblique, defined by a stout spine, and supplied along its length with peculiar setæ split at the ends. The second gnathopod similar, but with the anterior border of propodos twice the breadth of the joint, and the palm rather more oblique.



Basa of the last three pairs of pereiopoda broad, with the posterior margin expanded, convex, greatest breadth three-fourths of the length.

Third uropoda reaching only slightly beyond the extremity of the preceding pair; the outer branch one-jointed, twice as long as the peduncle, inner branch rudimentary, minute.

Telson reaching well beyond the end of the peduncle of the third uropod, hinder margin somewhat emarginate, lateral angles with 2 or 3 setæ.

Length about 4 mm.

*Habitat.* Ringwood in Hampshire, and Marlborough in Wiltshire. (In Europe recorded from Munich and Prague.)

This species was first described by Spence Bate from a single specimen found at Ringwood. From the figures given by de Rougemont [17. pl. i. figs. 1 & 2, and pl. ii. fig. 1], it appears that he really had before him either the present species or a closely allied one of *Crangonyx*; but his account of it adds nothing of importance to what was already known, and his assertion that it was merely a young stage of *Niphargus puteanus* has been already criticised by Humbert and Wrześniowski and shown to be erroneous. The species does not appear to have attracted further attention till 1896, when Vejdovsky published his important paper [21] and dealt exhaustively with its sense-organs and internal anatomy. In his revision of the Gammaridæ, Stebbing [31. p. 423] gave to the species described by Vejdovsky the new name *Eucrangonyx Vejdovskyi*, saying that it appeared to him to differ from Spence Bate's species: the points of difference to which he refers apparently being the possession of a small inner branch to the terminal uropoda and of an emargination in the telson. I have received from Mr. Stebbing a small mounted specimen of *Crangonyx subterraneus* from Marlborough, and have been able to compare it with mounted specimens of Vejdovsky's species; and after careful examination I have no doubt that both belong to the same species, and Professor Vejdovsky, who made a hasty comparison of the same specimens when I visited him in Prague in March last, was of the same opinion. In all points that can be observed the different specimens seem to be practically identical. The specimen from Marlborough is very small, and in its present mounted condition it is not possible to be quite certain whether it possesses a small inner branch to the terminal uropoda or not, though I think it has; but this

branch as figured by Vejdvosky is very small and delicate, and can no longer be seen in his specimens now that they are mounted in Canada balsam, but the rest of the uropod is so similar that I think the fine inner branch must be present in the Marlborough specimen also. In this specimen, again, the telson can be seen in side-view only, but it is evident that the two hinder angles project a little and bear setæ, as shown by Vejdvosky, and I think the posterior edge between them is slightly emarginate. In connection with this point it is perhaps worth while drawing attention to the fact that Jurinac has described considerable differences in the telson in the two sexes of his *Niphargus croaticus*, the male having the telson roundly indented (rather than cleft) for a third of its length only, while in the female the telson is sharply cleft to two-thirds of its length [37. pp. 12, 15, & 16, and pl. i. figs. 3 & 12]. In *Orangonyx mucronatus*, Forbes, again, the differences of the telson in the two sexes are quite startling; and I have recorded the fact that in *Calliopius subterraneus*, Chilton, the telson is rather more deeply emarginate in the male than in the female.

The lower antenna is shown in figure 4, *a.i.* It was wanting in Spence Bate's specimen; the articulations between the joints of the peduncle are slightly oblique, just as in *Orangonyx compactus*, Chilton.

The mouth-parts, so far as I have been able to examine them, are in minute agreement with those of the Prague specimens, the mandibles, second maxillæ, and maxillipedes being practically identical; the first maxillæ I have not seen.

The first gnathopod was described by Spence Bate as being larger than the second; and this character was made use of by Della Valle as a specific character for separating *Orangonyx subterraneus*, Bate, from *O. compactus*, Chilton. Vejdvosky has rightly shown that really the two gnathopoda differ only slightly in size, and that the second is actually the longer, though from his figures it appears that it is scarcely so stout in proportion; the same thing is true of the Marlborough specimen, as may be seen from a comparison of figs. 4, *gn.*<sup>1</sup> and 4, *gn.*<sup>2</sup>. For an account of the peculiar split setæ on the propoda of the gnathopoda, reference must be made to Vejdvosky's paper; they are present in the Marlborough specimen, but the specimen is very small and the details of them cannot now be made out.

The large size of the fourth side-plate is a peculiar character,

and was first pointed out by Vejdvsky; the lower margins of the first four side-plates are supplied with a few setæ, each arising from a slight indentation of the margin; this has been rather exaggerated in his figure 1, so as to make it appear as if the margins were actually crenate. His fig. 3 is more correct, though even here there is rather more crenation than in the specimen.

Accessory branchiæ have been described by Vejdvsky on the last three segments of the pereion; similar appendages had previously been described by Wrześniowski in *Boruta* and *Goplana*.

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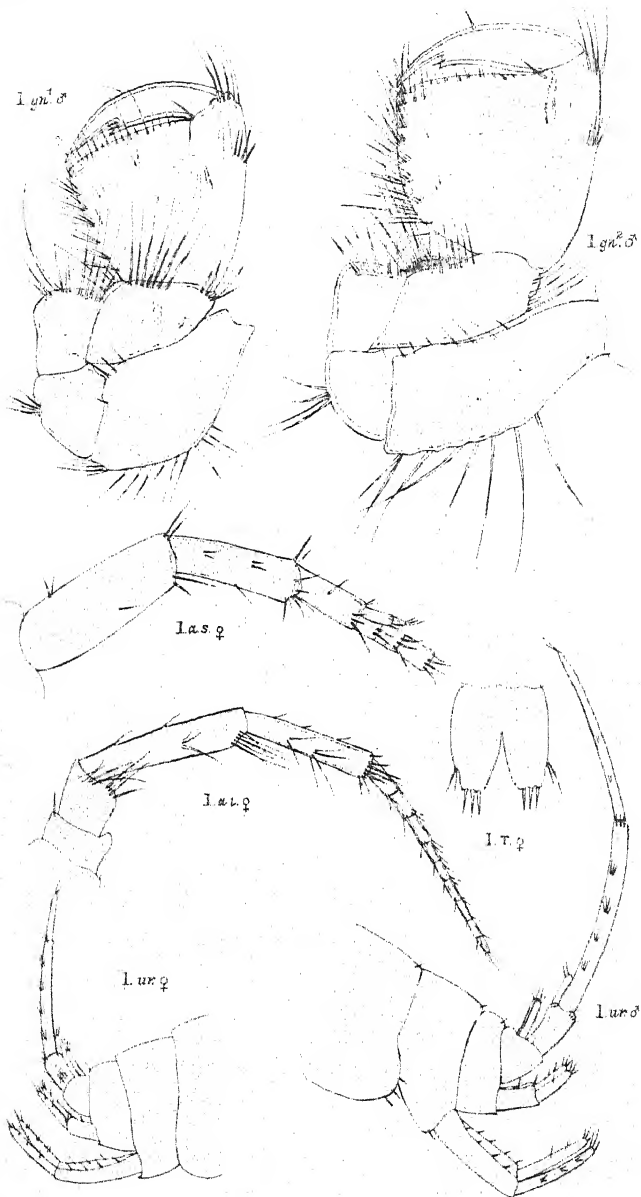
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#### EXPLANATION OF THE PLATES.

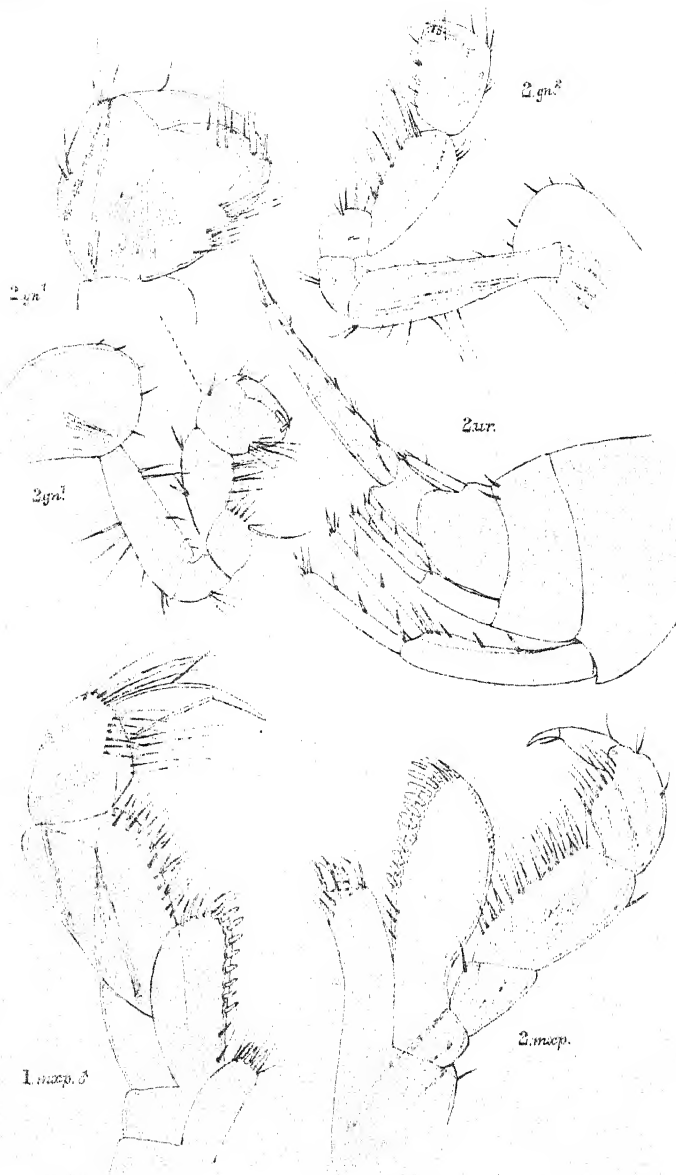
- a.s.* = superior antenna.  
*a.i.* = inferior antenna.  
*md.* = mandible.  
*maxp.* = maxillipede.  
*gn.<sup>1</sup>* = first gnathopod.  
*gn.<sup>2</sup>* = second gnathopod.  
*prp.<sup>3</sup>* = first pereopod.  
*ur.* = terminal portion of pleon with uropoda.  
*T.* = telson.



C. Chilton del.  
M. E. Parker lith.

Geo. West & Sons imp.

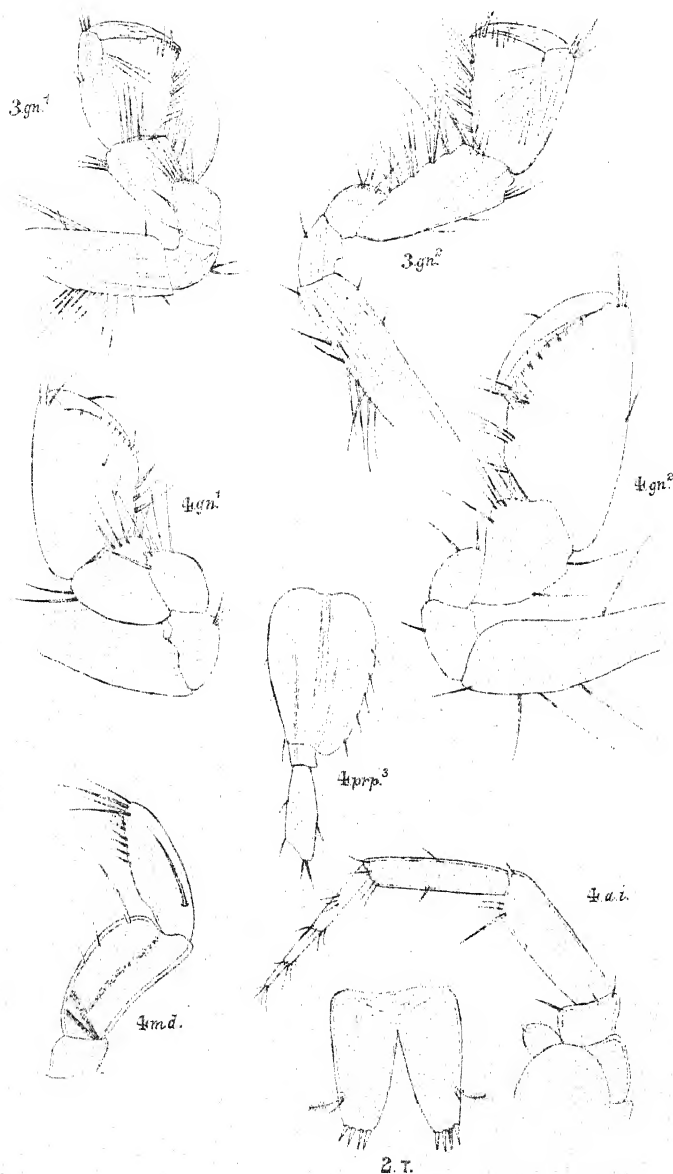
1. NIPHARGUS SUBTERRANEUS, Leach.



C. Chilton del.  
M. F. Parker lith.

Geo. West & Sons imp

1. NIPHARGUS SUBTERRANEUS, Leach.  
2. KOCHIANUS, Spence Bate.



C. Chilton del.  
M. Parker lith.

Geo. West & Sons imp.

2, 3, *NIPHARGUS KOCHIANUS*, Spence Bate.

4, *CRANGONGA SUBTERRANEUS*, Spence Bate.





## PLATE 16.

Fig. 1. *Niphargus subterraneus*, Leach. The sex of the specimen from which each drawing was made is indicated by the usual sign.

## PLATE 17.

Fig. 1. *Niphargus subterraneus*, Leach.

2. *Niphargus Kochianus*, Spence Bate, drawn from a specimen from Dublin.

## PLATE 18.

Fig. 1. *Niphargus Kochianus*, Spence Bate, Dublin specimen.

2. Ditto, from a Marlborough specimen.

3. *Crangonyx subterraneus*, Spence Bate.

(All the figures considerably magnified.)

FORAMINIFERA from the Lagoon at Funafuti.

By FREDERICK CHAPMAN, A.L.S., F.R.M.S.

[Read 6th December, 1900.]

(PLATES 19 & 20.)

## INTRODUCTION.

By the study of Foraminifera under abnormal or adverse conditions one is able to learn much that is of biological interest, and more of the real value of the so-called species, than by the mere examination of samples which have been obtained from ordinary extensive littoral or deep-sea deposits, formed under conditions more or less favourable.

So far as I know, we have never before had so good an opportunity of examining a foraminiferal lagoon fauna in detail. The present paper is based on the material dredged by Messrs. G. Halligan and A. E. Finckh across the lagoon of Funafuti; and this was courteously sent to us by Prof. T. Edgeworth David, of Sydney University, under whose direction the dredgings were made.

The dredgings were taken along a line running due E. and W. starting from below the Mission Church on Fongafale Islet, at intervals of half-a-mile, until the opposite rim of the Atoll was

reached at Fuafatu Islet \*. These dredgings were sent over in 6 oz. capsuled bottles and numbered consecutively 1 to 18.

The starting point for the dredgings, Fongafale, presents an unbroken rim; but on the contrary Fuafatu, on the opposite side of the Atoll, is situated on the part of the rim which is broken up by channels. These diverse features afford most interesting comparisons of the foraminiferal faunas at the two localities; for at the former place the Foraminifera have lived under more or less tranquil conditions; whereas those of the latter locality were subjected to the action of the currents and surf, and consequently had an abundant food-supply, and this could not fail to make a decided difference in the assemblage found there.

Although the lagoon of Funafuti is open to the sea by many broad channels, chiefly on the S.E. and N.W., the area itself is so large, about 9 miles along the line of the soundings, that we might well expect to find a facies in the middle of the lagoon differing from that near the rim of the Atoll.

The results obtained not only bear out this expectation, but they offer many new points with regard to the habits and preference of conditions exhibited by such lowly forms as the Rhizopoda, far exceeding anything we had anticipated.

The present collection is a remarkable object-lesson on the importance of environment in producing variations; and provided these conditions remain fixed for lengthened periods, the varieties may converge to definite centres of form, and come to be regarded as species. The simplicity of the Rhizopod-structure and the almost infinite adaptability of these animals to their environment enable us to point to innumerable connecting-links or intermediate forms, the despair of the systematist, which afford the biologist material for some important deductions and a general comparative study.

The present work has been chiefly carried out in the Geological Laboratory of the Royal College of Science; and I am indebted to Prof. Judd, C.B., F.R.S., for the facilities he has there given me.

\* See Map of Funafuti Atoll, p. 167.

## GENERAL ANALYSES OF THE SAMPLES.

The composition of the 18 samples of dredgings from the Lagoon are as follows:—

Sample No.	Distance from Mission Church.	Depth in fathoms.	Foraminifera.	Other Organisms.	Halimeda.
1.....	mile.	10	47 per cent.—Chiefly <i>Miliolina</i> , <i>Orbitolites</i> , <i>Textularia</i> , <i>Calcarina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	3 per. cent. — Lamellibranchs, Gastropods, Alcyonarian spicules, Echinoderma, Serpulae, Ostracoda and other Crustacea.	50 per cent.
2.....	1 mile.	15½	23 p. c.—Chiefly <i>Orbitolites</i> , <i>Calcarina</i> , <i>Textularia</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	2 p. c. — Echinoderma, Polyzoa, Lamellibranchs, Gastropods, Serpulae, Ostracoda.	75 p. c.
3.....	1½ miles.	20	5 p. c.—Chiefly <i>Sagenina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	5 p. c.—Lamellibranchs, Gastropods, and Serpulae.	99 p. c.
4.....	2 miles.	23	20 p. c.—Chiefly <i>Orbitolites</i> , <i>Planorbulina</i> , <i>Gypsina</i> , <i>Calcarina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	4 p. c. — Echinoderma, Polyzoa, Lamellibranchs, Gastropods, Serpulae, Ostracoda and other Crustacea.	76 p. c.
5.....	2½ miles.	24	14 p. c.—Chiefly <i>Sagenina</i> , <i>Gypsina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	1 p. c. — Echinoderma, Polyzoa, Lamellibranchs, Gastropods, Serpulae, and Crustacea.	85 p. c.
6.....	3 miles.	21	9 p. c.—Chiefly <i>Sagenina</i> , <i>Calcarina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	1 p. c. — Echinoderma, Polyzoa, Brachiopods, Gastropods, Lamellibranchs, Serpulae, Ostracoda and other Crustacea.	90 p. c.
7.....	3½ miles.	24	14 p. c.—Chiefly <i>Sagenina</i> , <i>Gypsina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	1 p. c.—Pteropods, Polyzoa, Lamellibranchs, Gastropods, Serpulae, and Ostracoda.	85 p. c.
8.....	4 miles.	26	2 p. c.—Chiefly <i>Sagenina</i> , <i>Gypsina</i> , <i>Nonionina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	1 p. c.—Sponges, Gastropods, Lamellibranchs, Serpulae, and Crustacea.	97 p. c.
9.....	4½ miles.	25	1 p. c.— <i>Sagenina</i> , <i>Bolivina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	1 p. c.—Serpulae, Lamellibranchs, Gastropods.	98 p. c.

TABLE (continued).

Sample No.	Distance from Mission Church.	Depth in fathoms.	Foraminifera.	Other Organisms.	<i>Halimeda</i> .
10.....	5 miles.	26	125 p. c.—Chiefly <i>Sagenina</i> , <i>Haddonina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	25 p. c.—Serpulæ, Gastropods, Lamellibranchs, Polyzoa, Pteropods, Ostracoda and other Crustacea.	85 p. c.
11.....	5½ miles.	25	125 p. c.—Chiefly <i>Haddonina</i> , <i>Carterina</i> , <i>Gypsina</i> , <i>Polytremata</i> , <i>Nonionina</i> , and <i>Amphistegina</i> .	25 p. c.—Echinoderma, Polyzoa, Lamellibranchs, Gastropods, and Crustacea.	85 p. c.
12.....	6 miles.	23	1 p. c.— <i>Sagenina</i> , <i>Gypsina</i> , <i>Polytremata</i> , and <i>Amphistegina</i> .	1 p. c.—Polyzoa. Gastropods, and Serpulæ.	98 p. c.
13.....	6½ miles.	26	9 p. c.—Chiefly <i>Carterina</i> , <i>Discorbina</i> , <i>Gypsina</i> , <i>Polytremata</i> , and <i>Amphistegina</i> .	1 p. c.—Polyzoa, Gastropods, and Serpulæ.	90 p. c.
14.....	7 miles.	16	9 p. c.—Chiefly <i>Orbitolites</i> , <i>Haddonina</i> , <i>Truncatulina</i> , <i>Calcarina</i> , <i>Gypsina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	1 p. c.—Echinoderma, Lamellibranchs, Gastropods, Heteropods, Serpulæ, and Ostracoda.	90 p. c.
15.....	7½ miles.	19	9 p. c.—Chiefly <i>Textularia</i> , <i>Calcarina</i> , <i>Gypsina</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	1 p. c.—Lamellibranchs, Gastropods, and Serpulæ.	90 p. c.
16.....	8 miles.	20	9 p. c.—Chiefly <i>Sagenina</i> , <i>Placopsilina</i> , <i>Carterina</i> , <i>Calcarina</i> , <i>Gypsina</i> , <i>Polytremata</i> , and <i>Amphistegina</i> .	1 p. c.—Polyzoa, Lamellibranchs, Gastropods, and Serpulæ.	90 p. c.
17.....	8½ miles.	12	90 p. c.—Chiefly <i>Spiroloculina</i> , <i>Miliolina</i> , <i>Hauerina</i> , <i>Peneroplis</i> , <i>Orbitolites</i> , <i>Textularia</i> , <i>Verneuilina</i> , <i>Globigerina</i> , <i>Cymbalopora</i> , <i>Discorbina</i> , <i>Calcarina</i> , <i>Gypsina</i> , <i>Polytremata</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	1 p. c.—Sponge spicules, Alcyonarian spicules, Echinoderma, Brachiopods, Lamellibranchs, Gastropods, and Ostracoda.	90 p. c.
18.....	9 miles.	½	98 p. c.—Chiefly <i>Spiroloculina</i> , <i>Miliolina</i> , <i>Hauerina</i> , <i>Peneroplis</i> , <i>Textularia</i> , <i>Verneuilina</i> , <i>Spirillina</i> , <i>Cymbalopora</i> , <i>Discorbina</i> , <i>Truncatulina</i> , <i>Tinaporus</i> , <i>Polytremata</i> , <i>Calcarina</i> , <i>Polystomella</i> , <i>Amphistegina</i> , and <i>Heterostegina</i> .	1 p. c.—Sponge spicules, Alcyonarian spicules, Echinoderma, Heteropods, and Ostracoda.	1 p. c.

By a reference to the foregoing Table, we find that the prevailing genus of the Foraminifera under all the varying conditions is *Amphistegina*. The specimens of this genus which are found in the middle of the lagoon are, as a rule, much smaller than those found within reach of the influence of marine currents from the outer side of the reef, whether through channels in the rim or through the submarine interstices of the reef-platform.

The spurred forms *Calcarina* and *Tinoporus* (slightly resembling each other in general form but not related) are both common near the rim at Fuafatu Islet, and on the opposite side of the lagoon at Fongafale Islet; but the latter genus rapidly disappears\* on travelling across the lagoon, and *Calcarina* only is found in the various samples taken from the lagoon-floor.

The number of genera of the Foraminifera found close to the lagoon-shore, near the Mission Church at Fongafale, is 21; but on the opposite side, at Fuafatu, the number is increased to 28. This is obviously owing to the greater influence of marine conditions and food-supply from the seaward face. At Fongafale this seems to be due to the passage of water through the reef-platform, and at Fuafatu to currents passing through channels in the rim of the Atoll or between the islets.

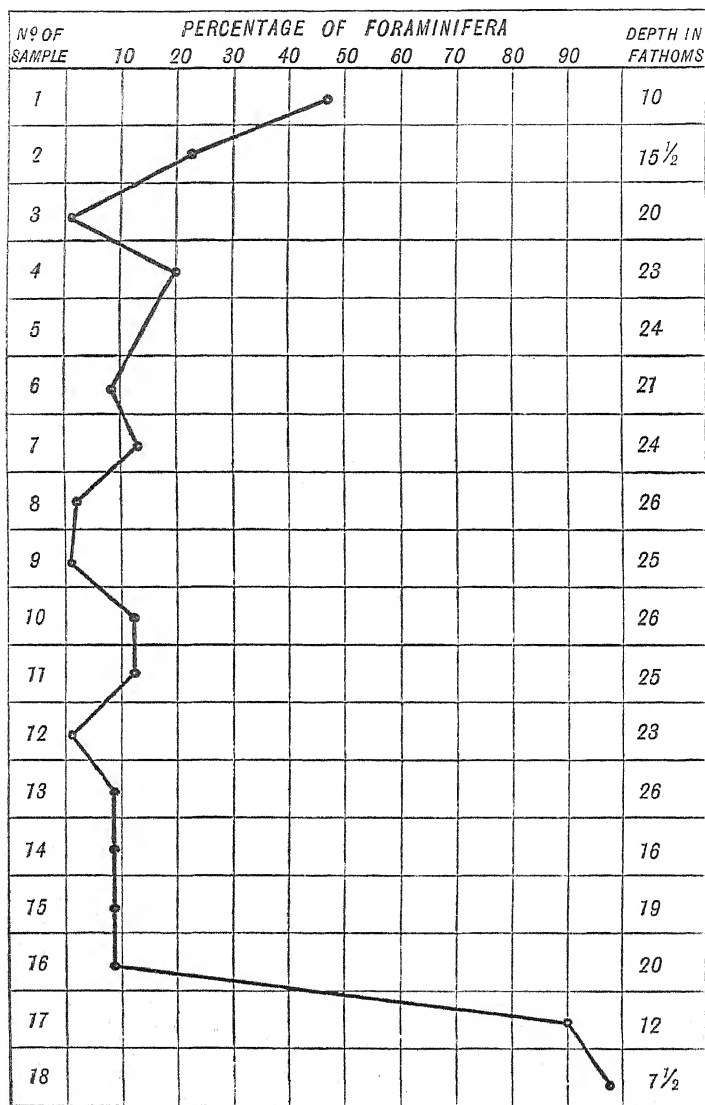
In the middle of the lagoon only three genera are present, namely, *Sagenina*, *Amphistegina*, and *Heterostegina*.

Whilst the greater number of generic forms gradually die out towards the centre of the lagoon, a few, with some special varieties, make their appearance and in tolerable abundance, in consequence of the more tranquil conditions prevailing there. A noteworthy form in this respect is *Carterina spiculotesta*, whose tiny brown tests are usually found attached to *Halimeda*-fronds. The thin papery form *Gypsina vesicularis* var. *squamiformis*, and the adherent *Planorbulina larvata* are also found under similar conditions.

#### PERCENTAGE COMPOSITION OF THE FORAMINIFERAL SAMPLES.

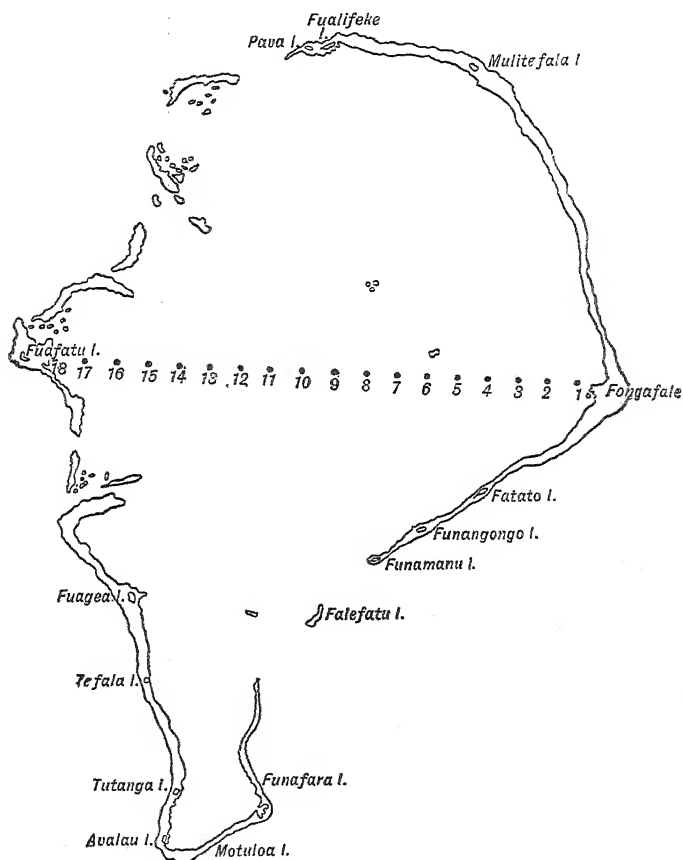
A Chart of the percentage composition of the samples with regard to the Foraminifera is given below. By this we see the almost equal proportion of *Halimeda* and the Foraminifera occurring near the rim of the Atoll at Fongafale Islet. There is

\* A solitary specimen of *Tinoporus baculatus*, much worn, and probably carried in by currents, was found in Sample 11,  $3\frac{1}{2}$  miles from the rim of the Atoll.



PERCENTAGE OF FORAMINIFERA.—Readings to the left of the zigzag line give percentages of Foraminifera; to the right, percentages of *Halimeda* and other miscellaneous organisms.

then a sudden drop  $1\frac{1}{2}$  miles out to .5 per cent. of Foraminifera, followed by an oscillation along the floor of the lagoon, and in no wise dependent upon depth. The percentage of Foraminifera



FUNAFUTI ATOLL.—Showing the principal Islets and the positions whence the Lagoon samples were taken.

here falls as low as 1 and never rises above 20. This low percentage is persistent until within 1 mile of the opposite rim near Fuafatu Islet, where there is a sudden rise to 90 per cent., which is further increased within  $\frac{1}{2}$  mile of the shore to 98 per cent.



## DESCRIPTION OF THE FORAMINIFERA \*.

## Family MILIOLIDÆ.

## Subfamily NUBECULARIINÆ.

NUBECULARIA, *Defrance* [1825].NUBECULARIA DIVARICATA, *Brady*. (Pl. 19. fig. 1.)

*Sagrina divaricata*, Brady, 1879, Quart. Journ. Micr. Sci. n. s., vol. xix. p. 276, pl. viii. figs. 22-24.

*Nubecularia divaricata*, Brady, 1884, Rep. Chall. vol. ix. p. 136, pl. lxxvi. figs. 11-15.

*N. divaricata*, Brady, Millett, 1898, Journ. R. Micr. Soc. p. 261, pl. v. fig. 4.

This rare form has previously been recorded from Humboldt Bay, Papua; off Raine Island, Torres Strait; off Tongatabu, Friendly Islands; and lately by Millett from three stations in the Malay Archipelago. Our specimen closely resembles that of the figure given by Millett, and it also shows the phialine termination of the aperture characteristic of this species.

Lagoon, Funafuti; very rare. Sample 18 ( $7\frac{1}{2}$  fathoms).

NUBECULARIA LUCIFUGA, *Defrance*.

*Nubecularia lucifuga*, Defrance, 1825, Dict. Sci. Nat. vol. xxv. p. 210, Atlas Zooph. pl. xlv. fig. 3.

*N. lucifuga*, Defrance, Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xvii. p. 250, pl. xxi. figs. 4-7.

*N. lucifuga*, Defrance, Millett, 1898, Journ. R. Micr. Soc. p. 261, pl. v. fig. 7.

A rare form in tropical areas. Recorded from Tongatabu, Friendly Islands; Malay Archipelago, etc. It is represented at Funafuti chiefly by spirally-wound specimens, originally attached to other organisms.

Lagoon, Funafuti; generally rare. Sample 1 (10 fathoms); sample 13 (26 fathoms); sample 17 (12 fathoms).

\* The synonymy of the species is here restricted chiefly to references subsequent to Brady's 'Challenger' Report (1884).

NUBECULARIA BRADYI, Millett. (Pl. 19. fig. 3.)

*Nubecularia inflata*, Brady, 1884, Rep. Chall. p. 135, pl. i. figs. 5-8.

*N. Bradyi* (*N. inflata* preoccupied), Millett, 1898, Journ. R. Micr. Soc. p. 261, pl. v. figs. 6a, b.

This species usually occurs in quite shallow water. It was obtained by the 'Challenger' off Honolulu, Sandwich Islands; off Tongatabu; off Tahiti; Nares Harbour, Admiralty Islands; and Balfour Bay, Kerguelen Island. It is common in the Greek Archipelago, and Millett found it in the Malay Archipelago. Our specimens do not show the fistulose or spouted tendency which the aperture assumes, shown in the specimens figured by Brady and Millett.

Lagoon, Funafuti; very rare. Sample 1 (10 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

NUBECULARIA LACUNENSIS, sp. nov. (Pl. 19. fig. 2.)

Test porcellanous, free, or (?) attached; consisting of a series of compressed and concave segments somewhat cuspid at the peripheral margin, and arranged in an obscurely rotaline manner. Superior face conical, depressed; inferior, flat. Diameter .55 millim.

Lagoon, Funafuti; very rare. Sample 18 ( $7\frac{1}{2}$  fathoms).

#### Subfamily MILIOLININÆ.

#### BILOCULINA, d'Orbigny [1826].

BILOCULINA OBLONGA, d'Orbigny.

*Biloculina oblonga*, d'Orbigny, 1839, in Sagra's Cuba, Foram. p. 163, pl. viii. figs. 21-23.

This species has the aboral end considerably swollen, and the inverted aperture of the penultimate chamber very apparent, thus differing from *B. elongata*, d'Orbigny, which is more regularly oval. D'Orbigny's specimens came from the neighbourhood of the Cuban coral-reefs.

Lagoon, Funafuti; very rare. Sample 8 (26 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

BILOCULINA SUBSPHERICA, d'Orbigny.

*Biloculina subspherica*, d'Orbigny, 1839, in Sagra's Cuba, Foram. p. 162, pl. viii. figs. 25-27.

This species was also described from the coral area around Cuba.

Lagoon, Funafuti; very rare. Sample 18 ( $7\frac{1}{2}$  fathoms).

*BILOCULINA RINGENS* (Lamarck).

*Miliolites ringens*, Lamarck, 1804, Ann. du Muséum, vol. v. p. 351; vol. ix. pl. xvii. fig. 1.

*Biloculina ringens* (Lam.), Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 220, pl. i. figs. 7-9.

*B. ringens* (Lam.), Millett, 1898, Journ. R. Micr. Soc. p. 262.

*B. ringens* (Lam.), Flint, 1899, Rep. U.S. National Mus. (1897) p. 294, pl. 39. fig. 2.

A widely distributed species both geographically and as regards depth of water. Millett found it generally distributed in the gatherings from the Malay Archipelago.

Lagoon, Funafuti; very rare. Sample 18 ( $7\frac{1}{2}$  fathoms).

*SPIROLOCULINA*, d'Orbigny [1826].

*SPIROLOCULINA ROBUSTA*, Brady.

*Spiroloculina robusta*, Brady, 1884, Rep. Chall. vol. ix. p. 150, pl. ix. figs. 7, 8.

*S. robusta*, Brady, Flint, 1899, Rep. U.S. Nat. Mus. (1897) p. 296, pl. 42. fig. 1.

This species was found by Dr. Brady in the dredgings near Culebra Island, West Indies, at a depth of 390 fathoms. The specimen from Funafuti is characteristic but small.

Lagoon, Funafuti; very rare. Sample 18 ( $7\frac{1}{2}$  fathoms).

*SPIROLOCULINA EXCAVATA*, d'Orbigny.

*Spiroloculina excavata*, d'Orbigny, 1846, Foram. Foss. Vienne, p. 271, pl. xvi. figs. 19-21.

*S. excavata*, d'Orb., Rupert Jones, 1895, Pal. Soc. Mon., Crag Foram. p. 106, pl. v. fig. 2; woodcuts, figs. 2 a, b.

*S. excavata*, d'Orb., Millett, 1898, Journ. R. Micr. Soc. p. 264.

*S. excavata*, d'Orb., Flint, 1899, Rep. U.S. Nat. Mus. (1897) p. 296, pl. 41. fig. 5.

Our specimen is small and very thin-shelled, somewhat resembling *S. impressa*, Terquem, but quite regular in shape.

Lagoon, Funafuti; very rare. Sample 14 (16 fathoms).

*SPIROLOCULINA NITIDA*, d'Orbigny, var. *FOVEOLATA*, Egger.  
(Pl. 19. fig. 4.)

*Spiroloculina foveolata*, Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 224, pl. i. figs. 33, 34.

*Spiroloculina nitida*, d'Orb. (reticulate variety), Millett, 1898, Journ. R. Micr. Soc. p. 266.

This is a very interesting variety which has been recorded from the Mauritius, the Malay Archipelago, and the S. Pacific. It is well developed at Funafuti, but in the external form perhaps more nearly resembles *S. planulata* (Lam.).

Lagoon, Funafuti; common. Sample 18 ( $7\frac{1}{2}$  fathoms).

*SPIROLOCULINA TORTUOSA*, sp. nov. (Pl. 19. fig. 5.)

This curious form somewhat resembles *S. lamella* of Egger\*, but is more regular in shape, and is of the *S. excavata* type. The sutural edges of the central series of chambers are strongly contorted. The extremities of the test resemble those of *S. impressa*, Terquem. Length .6 millim.

Lagoon, Funafuti; frequent. Sample 5 (24 fathoms); sample 15 (19 fathoms); sample 17 (12 fathoms).

*SPIROLOCULINA ANTILLARUM*, d'Orbigny.

*Spiroloculina antillarum*, d'Orbigny, 1839, in Sagra's Cuba, Foram. p. 149, pl. xi. figs. 3, 4.

The 'Challenger' collections yielded this species from only one station in the S. Atlantic, at 350 fathoms.

It is rare at Funafuti, and appears to be nearly related to the form *S. grata*, Terquem.

Lagoon, Funafuti; rare. Sample 18 ( $7\frac{1}{2}$  fathoms).

*SPIROLOCULINA GRATA*, Terquem.

*Spiroloculina grata*, Terquem, 1878, Mém. Soc. Géol. France, sér. 3, vol. i. p. 55, pl. x. figs. 14, 15.

*S. grata*, Terq., Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 224, pl. i. fig. 39.

This is one of the most frequent species of the genus in shallow-water sands of the coral-reefs. The specimens found here are typical in form and size.

Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 223, pl. i. figs. 24, 25.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 13 (26 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*SPIROLOCULINA TENUISEPTATA*, *Brady*.

*Spiroloculina tenuiseptata*, Brady, 1884, Rep. Chall. vol. ix. p. 153, pl. x. figs. 5, 6.

*S. tenuiseptata*, Brady, Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 223, pl. i. figs. 48, 49.

*S. tenuiseptata*, Brady, Millett, 1898, Journ. R. Micr. Soc. p. 265.

The occurrence of the above species in the lagoon-material is further evidence that it occurs in shallow water as well as in deeper; for Millett has lately recorded it from the Anchor Muds of the Malay Archipelago in depths of 12–14 fathoms. The 'Challenger' specimens were obtained from depths of more than 500 fathoms. The specimens from Funafuti are typical.

Lagoon, Funafuti; very rare. Sample 1 (10 fathoms); sample 2 ( $15\frac{1}{2}$  fathoms).

*SPIROLOCULINA ACUTIMARGO*, *Brady*.

*Spiroloculina acutimargo*, Brady, 1884, Rep. Chall. vol. ix. p. 154, pl. x. figs. 12–15.

*S. acutimargo*, Brady, Balkwill & Wright, 1885, Trans. R. Irish Acad. vol. xxviii. p. 323, fig. 1.

*S. acutimargo*, Brady, Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 222, pl. i. figs. 26–28.

*S. acutimargo*, Brady, Millett, 1898, Journ. R. Micr. Soc. p. 264.

As a rule the Funafuti specimens are small, with exception of an example from sample 1. The species is well distributed over tropical areas, and occurs in shallow and deeper water alike.

Lagoon, Funafuti; common in two places. Sample 1 (10 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOLINA*, *Williamson* [1858].

*MILIOLINA VALVULARIS* (*Reuss*).

*Triloculina valvularis*, Reuss, 1851, Zeitschr. deutsch. geol. Gesellsch. vol. iii. p. 85, pl. vii. fig. 56.

*Miliolina valvularis* (Reuss), Brady, 1884, Rep. Chall. vol. ix. p. 161, pl. iv. figs. 4, 5.

*M. valvularis*, Brady, Goës, 1894, Kongl. Svenska Vet.-Akad. Handl. vol. xxv. p. 115, pl. xxii. fig. 871.

*M. valvularis* (Reuss), Millett, 1898, Journ. R. Micr. Soc. p. 501, pl. xi. figs. 5–7.

*M. valvularis* (Reuss), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 299, pl. 44. fig. 5.

The Funafuti specimens are very small and occur in the deeper part of the lagoon.

Lagoon, Funafuti; very rare. Sample 10 (26 fathoms); sample 11 (25 fathoms).

*MILIOLINA CIRCULARIS* (*Bornemann*).

*Triloculina circularis*, Bornemann, 1855, Zeitschr. deutsch. geol. Gesellsch. vol. vii. p. 349, pl. xix. fig. 4.

*Miliolina circularis* (Born.), Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii, p. 235, pl. ii. figs. 61-63.

*M. circularis* (Born.), Jones, 1895, Pal. Soc. Mon., Crag Foram. p. 121, pl. v. fig. 4.

*M. circularis* (Born.), Millett, 1898, Journ. R. Micr. Soc. p. 499, pl. xi. figs. 1-3.

*M. circularis* (Born.), Flint, 1899, Rep. U. S. Nat. Mus., Rep. for 1897, p. 298, pl. 44. fig. 1.

A species met with off Cuba and the coast of Australia, amongst other localities. Millett has lately recorded it from the Malay Archipelago. The biloculine form of the species occurs in the lagoon at Funafuti.

Lagoon, Funafuti; specimens rather small. Sample 8 (26 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOLINA LABIOSA* (*d'Orbigny*).

*Triloculina labiosa*, d'Orbigny, 1839, in Sagra's Cuba, Foram. p. 178, pl. x. figs. 12-14.

*Miliolina labiosa* (d'Orb.), Millett, 1898, Journ. R. Micr. Soc. p. 502, pl. xi. figs. 8, 9.

*M. labiosa* (d'Orb.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 299, pl. 45. fig. 3.

This wild-growing form is not unfrequent in one of the samples from the Funafuti lagoon. It here appears to form a link between *Miliolina valvularis* and *Nubecularia inflata*.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOLINA SUBROTUNDA* (*Montagu*).

*Vermiculium subrotundum*, Montagu, 1803, Test. Brit. pt. 2, p. 521.

*Miliolina subrotunda* (Mont.), Millett, 1898, Journ. R. Micr. Soc. p. 502.

*M. subrotunda* (Mont.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 299, pl. 44. fig. 6.

The specimens found at Funafuti are characteristic.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 (7½ fathoms).

*MILIOLINA TRICARINATA (d'Orbigny).*

*Triloculina tricarinata*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 299, No. 7.

*Miliolina tricarinata* (d'Orb.), Millett, 1898, Journ. R. Micr. Soc. p. 502.

*M. tricarinata* (d'Orb.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 298, pl. 44. fig. 4.

The type form of this species is not common here, and varies somewhat in size.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 4 (23 fathoms); sample 18 (7½ fathoms).

*MILIOLINA TRICARINATA (d'Orb.), var. TERQUEMIANA, Brady.*

*Miliolina Terquemiana*, Brady, 1884, Rep. Chall. vol. ix. p. 166, pl. cxiv. fig. 1 a, b.

*M. tricarinata* (d'Orb.), striate variety, Millett, 1898, Journ. R. Micr. Soc. p. 503, pl. xi. figs. 10, 11.

This variety is distinguished by the numerous interrupted striae with which the surface of the test is covered. It was rare in the 'Challenger' collections, off Ceylon and the coast of Madagascar; but has been found not uncommon in the Malay Archipelago by Millett.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 (7½ fathoms).

*MILIOLINA TRICARINATA (d'Orb.), var. BERTHELINIANA, Brady.*

*Miliolina Bertheliniana*, Brady, 1884, Rep. Chall. vol. ix. p. 166, pl. cxiv. fig. 2.

*M. tricarinata* (d'Orb.), reticulated variety, Millett, 1898, Journ. R. Micr. Soc. p. 503, pl. xi. fig. 12.

This shallow-water form is usually rare, and occurs in two samples only, near the rim of the atoll at Funafuti.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 18 (7½ fathoms).

*MILIOLINA RETICULATA (d'Orbigny).*

*Triloculina reticulata*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 299, No. 9.

*Miliolina (Triloculina) reticulata*, d'Orbigny, Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 239, pl. ii. figs. 83, 84.

*Quinqueloculina reticulata* (d'Orb.), Schlumberger, 1893, Mém. Soc. Zool. France, vol. vi. p. 214, fig. 25, & pl. ii. fig. 62.

*Miliolina reticulata* (d'Orb.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 301, pl. 46. fig. 5.

This species occurs not uncommonly at Funafuti. The specimens from the lagoon comprise both the triloculine and the quinqueloculine forms.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOлина UNDOSA* (Karrer).

*Quinqueloculina undosa*, Karrer, 1867, Sitzungsab. Ak. Wiss. Wien, vol. lv. p. 361, pl. iii. fig. 3.

*Miliolina undosa* (Karrer), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 237, pl. ii. figs. 41, 42.

*M. undosa* (Karrer), Millett, 1898, Journ. R. Micr. Soc. p. 506, pl. xii. figs. 5 a-c.

*M. undosa* (Karrer), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 300, pl. 45. fig. 4.

This species varies considerably in size in different parts of the lagoon, and attains its largest dimensions in 12 fathoms near the lagoon-margin.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 4 (23 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOлина PARKERI*, Brady.

*Miliolina Parkeri*, Brady, 1884, Rep. Chall. vol. ix. p. 177, pl. vii. fig. 14.

*M. Parkeri*, Brady, Millett, 1898, Journ. R. Micr. Soc. p. 507, pl. xii. figs. 4 a, b.

Although this form is widely distributed, it appears to be restricted to the neighbourhood of coral-reefs.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOлина FERUSSACII* (d'Orbigny).

*Quinqueloculina Ferussacii*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 301, No. 18: Modèle No. 32.

*Miliolina Ferussacii* (d'Orb.), Millett, 1898, Journ. R. Micr. Soc. p. 507, pl. xii. figs. 6 a, b, 7 a, b, c.

This species is very numerous in some samples from the lagoon, but is never found far away from the margin. The variations from the typical form are very many, and they often approach *Spiroloculina* in the expansion and thinning of the test along the



median plane, by which the quinqueloculine form is reduced to a complanate series of chambers.

Lagoon, Funafuti. Sample 1 (10 fathoms); [sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms)].

*MILIOLINA AGGLUTINANS* (d'Orbigny).

*Quinqueloculina agglutinans*, d'Orbigny, 1839, in Sagra's Cuba, Foram. p. 168, pl. xii. figs. 11-13.

*Miliolina agglutinans* (d'Orb.), Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 239, pl. ii. fig. 55.

*M. agglutinans* (d'Orb.), Goës, 1894, K. Svenska Vet.-Akad. Handl. vol. xxv. p. 110, pl. xix. fig. 848, pl. xx. fig. 849.

*M. agglutinans* (d'Orb.), Millett, 1898, Journ. R. Micr. Soc. p. 508.

*M. agglutinans* (d'Orb.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 301, pl. 47. fig. 2.

The above form occurs on both sides and at the extreme margins of the lagoon at Funafuti. It is somewhat curious that in Sample 1 the tests are of the *M. Ferussacii* type, whilst on the opposite side of the atoll, in sample 18, they are all of the form of *M. seminulum*.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOLINA LINNEANA* (d'Orbigny).

*Triloculina Linneiana*, d'Orbigny, 1839, in Sagra's Cuba, Foram. p. 172, pl. ix. figs. 11-13.

*Miliolina Linneana* (d'Orb.), Millett, 1898, Journ. R. Micr. Soc. p. 509.

*M. Linneana* (d'Orb.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 300, pl. 46. fig. 3.

A single specimen only was found at Funafuti in the lagoon-dredgings, but it is of frequent occurrence in many of the beach-sands of the atoll.

Lagoon, Funafuti. Sample 1 (10 fathoms).

*MILIOLINA BICORNIS* (Walker & Jacob).

*Serpula bicornis*, Walker & Jacob, 1798, Adams' Essays, Kanmacher's ed. p. 633, pl. xiv. fig. 2.

*Miliolina bicornis* (W. & J.), Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 237, pl. ii. figs. 73, 74.

*M. bicornis* (W. & J.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 300, pl. 46. fig. 2.

The specimens found here are not very typical.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOLINA ALVEOLINIFORMIS*, *Brady*.

*Miliolina alveoliniformis*, Brady, 1879, Quart. Journ. Micr. Sci., n. s. vol. xix. p. 54.

*M. alveoliniformis*, Brady, Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 232, pl. ii. figs. 17-19.

This coral-reef species is restricted, in the lagoon-dredgings, to the margin. They are here small, some specimens being quite minute, measuring only .5 mm., with the exception of a single individual from Sample 17 (12 fathoms), which is 2.3 mm. in length.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 17 (12 fathoms); sample 18 (7½ fathoms).

*MILIOLINA OBLONGA* (*Montagu*).

*Vermiculium oblongum*, Montagu, 1803, Test. Brit. p. 522, pl. xiv. fig. 9.

*Miliolina oblonga* (Montagu), Rupert Jones, 1895, Pal. Soc. Mon., Crag Foram. p. 120, pl. iii. figs. 31, 32, & pl. v. fig. 5.

*M. oblonga* (Mont.), Millett, 1898, Journ. R. Micr. Soc. p. 267, pl. v. figs. 14 a, b.

*M. oblonga* (Mont.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 297, pl. 43. fig. 3.

The specimen found is very elongate, but otherwise characteristic.

Lagoon, Funafuti. Sample 4 (23 fathoms).

*MILIOLINA BOUEANA* (*d'Orbigny*).

*Quinqueloculina Boueana*, d'Orbigny, 1846, Foram. Foss. Vienne, p. 293, pl. xix. figs. 7-9.

*Miliolina Boueana* (d'Orbigny), Goës, 1894, K. Svenska Vet.-Akad. Handl. vol. xxv. p. 114, pl. xxi. fig. 865.

*M. Boueana* (d'Orb.), Millett, 1898, Journ. R. Micr. Soc. p. 510.

A solitary specimen, not quite typical, but nearest to the above species, was found in the lagoon-dredgings.

Lagoon, Funafuti. Sample 1 (10 fathoms).

*MILIOLINA BOSCIANA* (*d'Orbigny*). (Pl. 1. fig. 7.)

*Quinqueloculina Bosciana*, d'Orbigny, 1839, in Sagra's Cuba, Foram. p. 191, pl. xi. figs. 22-24.

*Miliolina Bosciana* (d'Orb.), Millett, 1898, Journ. R. Micr. Soc. p. 267, pl. vi. fig. 1.

The specimens from Funafuti are of the smooth-shelled type, and their sutures are not so deeply impressed as in the specimens figured by Millett.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOLINA FUNAFUTIENSIS*, sp. nov. (Pl. 19. fig. 6.)

Test elongate, distinctly triangular, sometimes with a well-marked keel; aperture slightly prolonged. Surface with delicate, slightly oblique, vertical striations. Length .5 mm.

The above form is of the type of *M. oblonga* and near *M. Bosciana*; it is distinguished chiefly by the triangular contour in cross-section. The striations are finer and more regular than those seen in the striated variety of *M. Bosciana* \*.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*MILIOLINA SCROBICULATA*, Brady.

*Miliolina scrobiculata*, Brady, 1884, Rep. Chall. vol. ix. p. 173, pl. cxiii. figs. 15 a-c.

This rare form is probably a depauperated variety of *M. bicornis*. It was found originally in shore-sand from Madagascar, and at Nares Harbour at 17 fathoms (Brady). The individual found at Funafuti is characteristic but small.

Lagoon, Funafuti. Sample 17 (12 fathoms).

#### Subfamily HAUERININÆ.

HAUERINA, d'Orbigny [1846].

HAUERINA ORNATISSIMA (Karrer).

*Quinqueloculina ornatissima*, Karrer, 1868, Sitzungsber. Ak. Wiss. Wien, vol. lviii. p. 151, pl. iii. fig. 2.

The specimens found in the lagoon are confined to the samples from near the margin. They are all very small, with one exception from Sample 17.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

#### Subfamily PENEROPLIDINÆ.

CORNUSPIRA, Schultze [1854].

CORNUSPIRA INVOLVENS, Reuss.

*Operculina involvens*, Reuss, 1850, Denkschr. Akad. Wiss. Wien, vol. i. p. 370, pl. xlv. fig. 20.

\* See Millett, Journ. R. Micr. Soc. 1898, p. 268, pl. vi. fig. 3 (*Miliolina Bosciana*, costate variety).

*Cornuspira involvens*, Reuss, 1863, Sitzungsab. Akad. Wiss. Wien, vol. xlviii. p. 39, pl. i. fig. 2.

*C. involvens*, Reuss, Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 303, pl. 48. fig. 3.

The above species is represented here by some rather dwarfed or immature examples.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 (7½ fathoms).

### PENEROPLIS, *Montfort* [1808].

PENEROPLIS PERTUSUS (*Forskål*).

*Nautilus pertusus*, *Forskål*, 1775, Descr. Anim. p. 125, no. 65.

*Peneroplis pertusus* (*Forskål*), Möbius, 1880, Foram. von Mauritius, p. 78, pl. iii. figs. 9-12.

*P. pertusus* (*Forskål*), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 304, pl. 48. fig. 4.

The forms of *Peneroplis*, usually regarded as varieties of a single species, are clearly related, but possibly do not show a more complete series of passage-forms than many other so-called species of Foraminifera. The specimens found at Funafuti fall into three groups—namely, the nautiloid form with dendritine apertures, the compressed nautiloid and prolonged form, and the delicate crosier-shaped type (subgenus *Monalysidium*). The first-named is by far the commonest form found at Funafuti.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 17 (12 fathoms); sample 18 (7½ fathoms).

PENEROPLIS ARIETINUS (*Batsch*).

*Nautilus (Lituus) arietinus* (pars), Batsch, 1791, Conch. See-sandes, p. 4, pl. vi. fig. 15, c.

*Peneroplis arietinus*, Parker, Jones & Brady, 1865, Ann. & Mag. Nat. Hist. ser. 3, vol. xvi. p. 26, pl. i. fig. 18.

*P. pertusus* (*Forsk.*), type c, Brady, 1884, Rep. Chall. vol. ix. p. 204, pl. xiii. figs. 18, 19, 22.

The rectilinear portion of the series in our specimens sometimes shows a tendency to curve either inward or outward. This type is evolved from an emaciated *P. pertusus* by the unrolling of the last coil or so of chambers.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 (7½ fathoms).

PENEROPLIS (MONALYSIDIUM) (?) POLITUS, *Chapman*. (Pl. 19. fig. 8.)

*Peneroplis (Monalysidium) politus*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 4, pl. i. fig. 5.

The specimen now figured, from the Funafuti lagoon, is a weak, thin-shelled peneroplid, and would probably end in a lengthened series such as the specimen previously figured, which however had lost its initial series.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

PENEROPLIS (MONALYSIDIUM) CYLINDRACEUS (*Lamarck*).

*Spirolina (Spirolinites) cylindracea*, Lamarck, 1804, Ann. du Muséum, vol. v. p. 245, no. 2.

*Peneroplis pertusus* (Forsk.), type *d*, Brady, 1884, Rep. Chall. vol. ix. p. 305, pl. xiii. figs. 20, 21.

The slender tests composed of a small spiral and a long chain of subglobular chambers are frequent in one sample from the lagoon. The surfaces of the chambers are relieved with delicate vertical striæ, which under a high power can be resolved into rows of minute tubercles.

Lagoon, Funafuti. Sample 17 (12 fathoms).

PENEROPLIS (MONALYSIDIUM) SOLLASI, *Chapman*.

*Peneroplis (Monalysidium) Sollasi*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 3, pl. i. fig. 6.

Fragments of the slender test of this species were found in the lagoon; they do not, however, exhibit the initial portion of the shell.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

ORBITOLITES, *Lamarck* [1801].

ORBITOLITES MARGINALIS (*Lamarck*). (Pl. 20. figs. 1-3.)

*Orbulites marginalis*, Lamarck, 1816, Hist. Nat. Anim. sans Vert. vol. ii. p. 196, no. 1.

*Orbitolites marginalis* (Lam.), Carpenter, 1883, Phil. Trans. vol. clxiv. p. 559, fig. 1.

*O. marginalis* (Lam.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 304, pl. 50. fig. 2; pl. 51. fig. 1.

This species is very characteristic of the shallow-water dredgings

of the Pacific Islands. Out of thirteen 'Challenger' Stations, eleven were from the Pacific. It has been found also in the West Indies, off Madagascar, in the Malay Archipelago, the Mediterranean, and the Red Sea.

More than half the specimens from the lagoon at Funafuti appear to have been at one time attached by a face of the shell to various living organisms, but chiefly to joints of *Halimeda*. Some examples were actually found in position on these calcareous plants. This habit of *Orbitolites* attaching itself to foreign objects is not unknown, but it appears to have only been noticed hitherto in the species *Orbitolites complanata*. The specimens thus found upon other organisms are invariably irregularly discoidal, and are generally concavo-convex in shape. They also have patches of redundant shell-growth scattered over the surfaces, sometimes arranged in radial strigillæ around the peripheral area.

Lagoon, Funafuti. Sample 1 (10 fathoms), some of the specimens beautifully smooth and regular, others concave or inflexed and with redundant patches of shell-growth on the surfaces (attached varieties); sample 2 (15½ fathoms), very irregular and inflexed, specimens large; sample 3 (20 fathoms), irregular specimens; sample 4 (23 fathoms), irregular specimens; sample 5 (24 fathoms), irregular specimens; sample 7 (24 fathoms), very irregular specimens; sample 8 (26 fathoms), a regular specimen; sample 14 (16 fathoms), irregular specimens; sample 15 (19 fathoms), an irregular specimen; sample 17 (12 fathoms), both regular and irregular specimens; sample 18 (7½ fathoms), regular and irregular specimens.

*ORBITOLITES COMPLANATA*, Lamarck.

*Orbitolites complanata*, Lamarck, 1801, Syst. Anim. sans Vert. p. 376.

*O. complanata*, Lam., Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 249, pl. iii. fig. 40.

Although rarer than the foregoing species, *O. complanata* is common and fairly typical in two of the lagoon samples. The variety *plicata* of Dana\* is found in some abundance in the sand from the lagoon beach at Funafuti, but it does not occur

\* *Marginopora vertebralis*, Blainville, var. *plicata*, J. D. Dana, 1848, Wilkes' U.S. Expl. Exped., Rep. Zooph. p. 706, pl. 60. figs. 9, 9 a, b.

in the dredgings. It is somewhat surprising that *O. duplex* should be altogether wanting in these foraminiferal deposits.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 2 (15½ fathoms).

### Family ASTORRHIZIDÆ.

#### Subfamily RHABDAMMININÆ.

##### HYPERAMMINA, *Brady* [1878].

##### HYPERAMMINA RAMOSA, *Brady*.

*Hyperammina ramosa*, Brady, 1879, Quart. Journ. Micr. Sci., n. s. vol. xix. p. 33, pl. iii. figs. 14, 15.

*H. ramosa*, Brady, Goës, 1893, Arctic and Scand. Foram., Sv. Vet.-Ak. Handl. vol. xxv. p. 18, pl. iv. figs. 61, 62.

*H. ramosa*, Brady, Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 270, pl. 11. fig. 1.

It is unusual to meet with this species in low latitudes, but it has already been recorded by Goës from the Pacific and the Caribbean Sea; and by Flint from Cape Hatteras and the Gulf of Mexico.

The specimens from Funafuti lagoon exhibit the primordial segment, and the test is yellowish brown and composed of very slender and minute calcisponge-spicules.

Lagoon, Funafuti. Sample 15 (19 fathoms).

##### SAGENINA, *Chapman* [1900].\*

##### SAGENINA FRONDESCENS (*Brady*).

*Sagenella frondescens*, Brady, 1879, Quart. Journ. Micr. Sci., n. s. vol. xix. p. 41, pl. v. fig. 1.

*S. frondescens*, Brady, 1884, Rep. Chall. vol. ix. p. 278, pl. xxviii. figs. 14, 15.

*Sagenina frondescens* (Brady), Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 4, pl. i. figs. 1, 2; pl. ii. figs. 1, 2.

This is one of the most characteristic and widely spread organisms both of the lagoon and the outer reef. It is an attached form, and makes its growth usually upon the fronds of *Halimeda*, but is also found growing upon other objects which present a suitable surface for the purpose.

\* *Sagenella*, Brady, 1879, name preoccupied for a genus of Polyzoa, see Journ. Linn. Soc., Zool. vol. xxviii. p. 4.

Unlike the other Foraminifera, this form is conspicuously absent from dredgings taken immediately inside the rim of the atoll on the opposite sides of the lagoon, and increases in numbers and character towards the middle of the lagoon.

*S. frondescens* is apparently restricted to the S. Pacific.

Lagoon, Funafuti. Sample 3 (20 fathoms); sample 4 (23 fathoms); sample 5 (24 fathoms); sample 6 (21 fathoms); sample 7 (24 fathoms); sample 8 (26 fathoms); sample 9 (25 fathoms); sample 10 (26 fathoms); sample 12 (23 fathoms); sample 14 (16 fathoms); sample 15 (19 fathoms); sample 16 (20 fathoms).

### Family LITUOLIDÆ.

#### Subfamily LITUOLINÆ.

##### PLACOPSILINA, d'Orbigny [1850].

##### PLACOPSILINA CENOMANA, d'Orbigny.

*Placopsilina cenomana*, d'Orbigny, 1850, Prodr. Paléont. vol. ii. p. 135, No. 758.

This species is not a common form, but it is generally distributed in tropical and subtropical areas. It was found by the 'Challenger' at five or six stations amongst the coral-reefs of the Pacific.

The specimens found in the lagoon at Funafuti are typical. The test sometimes branches towards the end.

Lagoon, Funafuti. Sample 5 (24 fathoms); sample 7 (24 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms).

##### HADDONIA, Chapman [1898].

##### HADDONIA TORRESIENSIS, Chapman.

*Haddonina torresiensis*, Chapman, 1898, Journ. Linn. Soc., Zool. vol. xxvi. p. 452, pl. xxviii. figs. 1-5 and woodcut p. 453.

*H. torresiensis*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 6.

The particular part of the lagoon where this species appears to thrive best is near the middle, from sample 10, and four miles from the nearest reef; at this place the *Haddoninae* have a peculiar habit of sheltering between the fronds of *Halimeda*, and, by adhering at various points to the joints, cement them into a more or less coherent mass.



Lagoon, Funafuti. Sample 6 (21 fathoms); sample 7 (24 fathoms); sample 10 (26 fathoms); sample 11 (25 fathoms); sample 14 (16 fathoms); sample 15 (19 fathoms); sample 16 (20 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

### Subfamily TROCHAMMININÆ.

#### CARTERINA, *Brady* [1884].

##### CARTERINA SPICULOTESTA (*Carter*).

*Rotalia spiculotesta*, Carter, 1877, Ann. Mag. Nat. Hist. ser. 4, vol. xx. p. 470, pl. xvi.; *ibid.* 1879, ser. 5, vol. iii. p. 414; *ibid.* 1880, ser. 5, vol. v. p. 452.

*Carterina spiculotesta* (Carter), Brady, 1884, Rep. Chall. vol. ix. p. 346, pl. xli. figs. 7-10.

*C. spiculotesta* (Carter), Millett, 1899, Journ. R. Micr. Soc. p. 365.

This curious little organism, although resembling *Trochammina* in general form and outline, constructs its test of minute calcareous spicules of a fusiform shape. The primary whorls of the test are usually strongly coloured a deep reddish brown, presumably by the sarcode; the last whorl or so of the shell is more often white, although in one example (a fully grown specimen from Funafuti) is strongly coloured to the periphery. The little spicular bodies appear to be somewhat felted together in the central part of the test in each segment, but lie more or less parallel along the outer borders.

*C. spiculotesta* has been found in the Gulf of Suez, the Red Sea, the Gulf of Manaar, the Malay Archipelago, and the S. Pacific. It is normally adherent, and is found attached to *Halimeda* and *Lithothamnion* at Funafuti.

Lagoon, Funafuti. Sample 10 (26 fathoms); sample 11 (25 fathoms); sample 13 (26 fathoms); sample 15 (19 fathoms); sample 16 (20 fathoms).

### Family TEXTULARIIDÆ.

#### Subfamily TEXTULARINÆ.

##### TEXTULARIA, *DeFrance* [1824].

##### TEXTULARIA FOLIUM, *Parker & Jones*.

*Textularia folium*, Parker & Jones, 1865, Phil. Trans. vol. clv. pp. 370, 420, pl. xviii. fig. 19.

*T. folium*, P. & J., Moebius, 1880, Foram. Mauritius, p. 92, pl. viii. figs. 16, 17.

The principal localities for this delicate little species are situated in the Pacific, where it is found in the shallow water of coral-reefs. It has also occurred at Mauritius, Bass Strait, Torres Strait, and Melbourne.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

*TEXTULARIA CONICA*, d'Orbigny.

*Textularia conica*, d'Orbigny, 1839, in Sagra's Cuba, Foram. p. 143, pl. i. figs. 19, 20.

*T. conica*, d'Orb., Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 273, pl. vi. figs. 34-36.

*T. conica*, d'Orb., Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 285, pl. 29. fig. 6.

This common and widely distributed species is best represented in the lagoon in the samples close to the rim of the atoll. In all cases they are rather undersized.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 4 (23 fathoms); sample 14 (16 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*TEXTULARIA RUGOSA* (Reuss).

*Plecanium rugosum*, Reuss, 1869, Sitzungsab. Ak. Wiss. Wien, vol. lix. p. 453, pl. i. figs. 3 a, b.

*Textularia rugosa* (Reuss), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 284, pl. 29. fig. 2.

This striking coral-reef species is well represented in the lagoon dredgings. It is one of the exceptions to the rule that the best developed specimens occur near the margin of the lagoon, for extraordinarily large examples were found in samples 6 and 15, at 3 and  $1\frac{1}{2}$  miles respectively from the edge. One of these measures 5 mm. in length; whereas the usual length of large specimens is 2 mm.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 2 ( $15\frac{1}{2}$  fathoms); sample 6 (21 fathoms); sample 7 (24 fathoms); sample 15 (19 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*VERNEUILINA*, d'Orbigny [1840].

*VERNEUILINA SPINULOSA*, Reuss.

*Verneuilina spinulosa*, Reuss, 1849, Denkschr. Ak. Wiss. Wien, vol. i. p. 347, pl. xlvii. figs. 12 a-c.

*F. spinulosa*, Reuss, Egger, 1893, Abhandl. bayer. Ak. Wiss., Cl. ii. vol. xviii. p. 281, pl. vii. figs. 11, 14-16.

The lagoon specimens are below the average size. The examples from dredgings farthest from the margin of the lagoon have lost their delicate spines, which seems to prove that they have been carried in, in common with many other species, by the action of currents.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 4 (23 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

#### VALVULINA, *d'Orbigny*.

VALVULINA DAVIDIANA, *Chapman*.

*Valvulina Davidiana*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 9, pl. i. fig. 4.

A fully developed example of this interesting species was found near the margin of the lagoon.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

#### CLAVULINA, *d'Orbigny* [1826].

CLAVULINA PARISIENSIS, *d'Orbigny*.

*Clavulina Parisiensis*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 268, No. 3: Modèle No. 66.

*C. Parisiensis*, d'Orb., Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 289, pl. 35. figs. 2, 3.

The specimen found in the lagoon is a very neat example with the sutures of the chambers perfectly distinct.

Lagoon, Funafuti. Sample 1 (10 fathoms).

#### Subfamily BULIMININÆ.

#### BOLIVINA, *d'Orbigny* [1839].

BOLIVINA PUNCTATA, *d'Orbigny*.

*Bolivina punctata*, d'Orbigny, 1839, Foram. Amér. Mérid. p. 61, pl. viii. figs. 10-12.

*B. punctata*, d'Orb., Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 292, pl. 38. fig. 1.

A single specimen of this delicate form was found in the central part of the lagoon.

Lagoon, Funafuti. Sample 9 (25 fathoms).

*BOLIVINA LIMBATA*, *Brady*.

*Bolivina limbata*, Brady, 1881, Quart. Journ. Micr. Sci., n. s. vol. xxi. p. 57.

A typical example of this species was found near the margin of the lagoon.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

*BOLIVINA TORTUOSA*, *Brady*.

*Bolivina tortuosa*, Brady, 1881, Quart. Journ. Micr. Sci., n. s. vol. xxi. p. 57.

*B. tortuosa*, Brady, Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 298, pl. viii. figs. 43, 44.

A widely distributed form in warm areas. The specimen from the lagoon is rather below the average size.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

## Family LAGENIDÆ.

## Subfamily POLYMORPHININÆ.

*SAGRINA* (*d'Orbigny*, 1839) emend. *Parker & Jones* [1865].

*SAGRINA RAPHANUS*, *Parker & Jones*.

*Uvigerina* (*Sagrina*) *raphanus*, Parker & Jones, 1865, Phil. Trans. vol. clv. p. 364, pl. xviii. figs. 16, 17.

*Siphogenerina* (*Sagrina*) *raphanus*, P. & J., Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 317, pl. ix. fig. 36.

In common with the other true reef-loving Foraminifera, this species is confined to samples from the margin of the lagoon.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

## Family GLOBIGERINIDÆ.

*GLOBIGERINA*, *d'Orbigny* [1826].

*GLOBIGERINA BULLOIDES*, *d'Orbigny*.

*Globigerina bulloides*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 277, No. 1: Modèles, Nos. 17 & 76.

*G. bulloides*, d'Orb., Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 321, pl. 69, fig. 2.

The conditions under which these specimens lived are not

favourable to the growth of this pelagic foraminifer, for the specimens found are all below the usual size and are restricted to the lagoon-margin.

Lagoon, Funafuti. Sample 2 ( $15\frac{1}{2}$  fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*GLOBIGERINA BULLOIDES*, d'Orbigny, var. *TRILOBA*, Reuss.

*Globigerina triloba*, Reuss, 1849, Denkschr. Ak. Wiss. Wien, vol. i. p. 374, pl. xlvii. figs. 11 a-e.

*G. bulloides*, d'Orb., var. *triloba*, Reuss, Brady, 1884, Rep. Chall. vol. ix. p. 595, pl. lxxix. figs. 1, 2; pl. lxxxi. figs. 2, 3.

This variety accompanies the type form in two out of the three occurrences in the lagoon. Similarly these are small starved specimens.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

## Family ROTALIIDÆ.

### Subfamily SPIRILLININÆ.

#### SPIRILLINA, Ehrenberg [1841].

*SPIRILLINA TUBERCULO-LIMBATA*, Chapman.

*Spirillina tuberculo-limbata*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 11, pl. i. figs. 8 a-c.

Although in general form this is like *Spirillina inæqualis*, Brady, the two faces of the test are differently decorated to that species, there being no tubercles on the inferior face. It is confined to one point near the lagoon-margin.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

*SPIRILLINA SPINIGERA*, Chapman. (Pl. 19. figs. 9 & 10.)

*Spirillina spinigera*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 10, pl. i. figs. 7 a-c.

The material from the lagoon affords us many additional specimens of this interesting form. The specimen (fig. 9) showing the long spinous decoration appears to belong to the *megalospheric* type of shell; whilst the larger forms, which by the way are more numerous, and which have a thinner peripheral edge, serrate rather than spinous (fig. 10), are presumably *microspheric*.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

## Subfamily ROTALINÆ.

CYMBALOPORA, *Hagenow* [1850].CYMBALOPORA POEYI (*d'Orbigny*).

*Rosalina Poeyi*, *d'Orbigny*, 1839, *Foram. Cuba*, p. 100, pl. iii. figs. 18-20.

*Cymbalopora Poeyi* (*d'Orb.*), *Egger*, 1893, *Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii.* p. 381, pl. xviii. figs. 51, 52.

*C. Poeyi* (*d'Orb.*), *Flint*, 1899, *Rep. U.S. Nat. Mus., Rep. for 1897*, p. 326, pl. 72. fig. 1.

When living, the central part of the test of this species is usually of a rose or red-brown tint. The specimens from the lagoon are invariably white, and those from near the middle of the lagoon are discoloured and yellowish-brown. This leads one to conclude that these and many other forms are not actually living in the lagoon, but are carried in by ocean currents.

The depressed variety sometimes found accompanying the typical forms is here very rare.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 14 (26 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

CYMBALOPORA TABELLEFORMIS, *Brady*.

*Cymbalopora tabellæformis*, *Brady*, 1884, *Rep. Chall. vol. ix.* p. 637, pl. cii. figs. 15-18.

*C. tabellæformis*, *Brady*, *Egger*, 1893, *Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii.* p. 382, pl. xviii. figs. 54, 55.

The specimens from the lagoon are typical but rather small. The species is chiefly known from the coral-reefs of the islands of the Pacific, and it also occurs off Mauritius.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

CYMBALOPORA (TRETOMPHALUS) BULLOIDES (*d'Orbigny*).

*Rosalina bulloides*, *d'Orbigny*, 1839, *Foram. Cuba*, p. 104, pl. iii. figs. 2-5.

*Tretomphalus bulloides* (*d'Orbigny*), *Möbius*, 1880, *Foram. Mauritius*, p. 98, pl. x. figs. 6-9.

*Cymbalopora (Tretomphalus) bulloides* (*d'Orb.*), *Brady*, 1884, *Rep. Chall. vol. ix.* p. 638, pl. cii. figs. 7-12.

*C. bulloides* (*d'Orb.*), *Egger*, 1893, *Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii.* p. 381, pl. xviii. fig. 53.

It is very probable that the examples found in the lagoon have floated in by the action of currents, especially since this form is

usually found near the surface of the ocean. Our specimens are of the normal size.

Lagoon, Funafuti. Sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

DISCORBINA, *Parker & Jones* [1862].

DISCORBINA ARAUCANA (*d'Orbigny*).

*Rosalina araucana*, d'Orbigny, 1839, Foram. Amér. Mérid. p. 44, pl. vi. figs. 16-18.

*Discorbina araucana* (d'Orb.), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 386, pl. xiv. figs. 4-6.

A single specimen, rather small, was found in the lagoon.

Lagoon, Funafuti. Sample 16 (20 fathoms).

DISCORBINA RUGOSA (*d'Orbigny*).

*Rosalina rugosa*, d'Orbigny, 1839, Foram. Amér. Mérid. p. 42, pl. ii. figs. 12-14.

*Discorbina rugosa* (d'Orb.), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 383, pl. xv. figs. 1-3.

*D. rugosa* is not uncommon in the lagoon dredgings. One of the specimens is coloured a warm-brown.

Lagoon, Funafuti. Sample 10 (26 fathoms); sample 14 (16 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

DISCORBINA GLOBULARIS (*d'Orbigny*).

*Rosalina globularis*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 271, pl. xiii. figs. 1-4: Modèle No. 69.

*Discorbina globularis* (d'Orb.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 327, pl. 72. fig. 2.

Our specimens are somewhat variable in size, and the species is not uncommon in the lagoon.

Lagoon, Funafuti. Sample 10 (26 fathoms); sample 15 (19 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

DISCORBINA SAULCII (*d'Orbigny*).

*Rosalina Saulcii*, d'Orbigny, 1839, Foram. Amér. Mérid. p. 42, pl. ii. figs. 9-11.

*Discorbina Saulcii* (d'Orb.), Parker & Jones, 1872, Quart. Journ. Geol. Soc. vol. xxviii. p. 156.

*D. Saulcii* (d'Orb.), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 392, pl. xv. figs. 51-53.

The specimen from the lagoon is characteristically flattened

on the superior face, and the colour of the shell is not unlike that of *D. rugosa*.

Lagoon, Funafuti. Sample 17 (12 fathoms).

*DISCORBINA CONCINNA*, *Brady*.

*Discorbina concinna*, Brady, 1884, Rep. Chall. vol. ix. p. 646, pl. xc. figs. 7, 8.

*D. concinna*, Brady, Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 388, pl. xv. figs. 22-24.

In addition to the localities for this species given by Brady, the 'Gazell' collected it from Cape Verde, Mauritius, and West of Australia.

Lagoon, Funafuti. Sample 17 (12 fathoms).

*DISCORBINA VILARDEBOANA* (*d'Orbigny*).

*Rosalina Vilardeboana*, d'Orbigny, 1839, Foram. Amér. Mérid. p. 44, pl. vi. figs. 13-15.

*Discorbina Vilardeboana* (d'Orb.), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 387, pl. xv. figs. 13-15.

This form in common with the other *Discorbinae* was found at the lagoon-margin.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

*DISCORBINA PILEOLUS* (*d'Orbigny*).

*Valvulina pileolus*, d'Orbigny, 1839, Foram. Amér. Mérid. p. 47, pl. i. figs. 15-17.

*Discorbina pileolus* (d'Orb.), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 390, pl. xv. figs. 61-63.

This species is a well-known form from the Pacific; and is frequent in shallow-water dredgings in tropical and subtropical areas. The Funafuti specimens are typical but not common.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

*DISCORBINA ORBICULARIS* (*Terquem*).

*Rosalina orbicularis*, Terquem, 1876, Anim. sur la Plage de Dunkerque, p. 75, pl. ix. figs. 4 a, b.

*Discorbina orbicularis* (Terq.), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 389, pl. xv. figs. 16-18, 76-78.

This is well represented in point of numbers, and the specimens are fairly typical. A solitary specimen occurred near the middle of the lagoon.

Lagoon, Funafuti. Sample 8 (26 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).



*DISCORBINA TUBEROCAPITATA, Chapman.*

*Discorbina tubero capitata*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 11, pl. i. figs. 9 a-c.

This striking form is not so well developed in the lagoon samples, as in the shallow-water dredgings on the outer part of the reef.

Lagoon, Funafuti. Sample 11 (25 fathoms); sample 13 (26 fathoms); sample 16 (20 fathoms).

*DISCORBINA RARESCENS, Brady.*

*Discorbina rarescens*, Brady, 1884, Rep. Chall. vol. ix. p. 651, pl. xc. figs. 2, 3, and 4?

*D. rarescens*, Brady, Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 388, pl. xv. figs. 45-47.

The species which have undoubtedly lived in the lagoon are not numerous, and apparently the present form is an example which has adapted itself to those conditions. It appears to grow attached to the surfaces of other organisms such as *Halimeda*.

Brady records this species from the Philippines and Torres Strait, and Egger from West Africa and Western Australia.

Lagoon, Funafuti. Sample 4 (23 fathoms); sample 6 (21 fathoms); sample 13 (26 fathoms); sample 14 (16 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms).

*PLANORBULINA, d'Orbigny [1826].**PLANORBULINA MEDITERRANENSIS, d'Orbigny.*

*Planorbulina mediterraneensis*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 280, pl. xiv. figs. 4-6: Modèle No. 79.

*P. mediterraneensis*, d'Orb., Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 380, pl. xiv. figs. 24-26.

*P. mediterraneensis*, d'Orb., Goës, 1894, Kongl. Svenska Vet.-Ak. Handl., vol. xxv. No. 9, p. 91, pl. xv. fig. 786.

*P. mediterraneensis*, d'Orb., Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 328, pl. 72. fig. 6.

This species has a wide geographical distribution. It has already been recorded from the Pacific Ocean. The lagoon specimens are small and arrested in their growth, and are very like the specimen figured by Goës to which reference is given above.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 13 (26 fathoms); sample 18 (7½ fathoms).

*PLANORBULINA LARVATA*, *Parker & Jones*.

*Planorbulina vulgaris*, var. *larvata*, Parker & Jones, 1860, Ann. Mag. Nat. Hist. ser. 3, vol. v. p. 294.

*P. larvata*, Parker & Jones, 1865, Phil. Trans. vol. clv. p. 379, pl. xix. fig. 3 a, b.

*P. larvata*, P. & J., Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 189, pl. xiv. fig. 31.

Amongst the several planorbuline forms this is one which possesses most individuality, the specimens being nearly all characteristic.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 4 (23 fathoms); sample 6 (21 fathoms); sample 7 (24 fathoms); sample 8 (26 fathoms).

*PLANORBULINA LARVATA*, *Parker & Jones*, var. *CRISPATA*, nov. (Pl. 20. fig. 5.)

This is a curious aberrant form in which the several series of chambers have been added to in a semicircular manner, instead of a discoidal, giving rise to a curled or semilunar-shaped test. Greatest length 2.2 mm.

Lagoon, Funafuti. Sample 5 (24 fathoms).

*PLANORBULINA ACERVALIS*, *Brady*, var. *FIMBRIATA*, nov. (Pl. 20. fig. 4.)

This example differs from the usual form in having the peripheral series of chambers separated and slightly flattened and squared at the extremities, producing a kind of fringe around the discoidal test. The central area is smoother than usual, but shows a certain amount of acervuline segmentation forming a superficial series of chamberlets. Diameter 1.4 mm.

Lagoon, Funafuti. Sample 8 (26 fathoms).

*TRUNCATULINA*, *d'Orbigny* [1826].

*TRUNCATULINA VARIABILIS*, *d'Orbigny*.

*Truncatulina variabilis*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 279, No. 8.

*T. variabilis*, d'Orb., Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 404, pl. xvi. figs. 57-59, 63, 64.

Our specimen was found at some distance from the edge of the lagoon; and the test being of a brown tint in the central portion appears to point to the conclusion that the organism was living *in situ*.

Lagoon, Funafuti. Sample 13 (26 fathoms).

TRUNCATULINA PYGMÆA, *Hantken*.

*Truncatulina pygmæa*, Hantken, 1875, Mittheil. Jahrb. ung. geol. Anstalt, vol. iv. p. 78, pl. x. fig. 8.

*T. pygmæa*, Hantken, Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 400, pl. xvi. figs. 60-62.

*T. pygmæa*, Hantken, Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 334, pl. 77. fig. 6.

This is a species of *Truncatulina* usually confined to deep water.

Lagoon, Funafuti. Sample 17 (12 fathoms).

TRUNCATULINA UNGERIANA (*d'Orbigny*).

*Rotalina Ungeriana*, d'Orbigny, 1846, Foram. Foss. Vienne, p. 157, pl. viii. figs. 16-18.

*Truncatulina Ungeriana* (d'Orb.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 333, pl. 77. fig. 2.

This species is represented by a very small specimen from the lagoon.

Lagoon, Funafuti. Sample 16 (20 fathoms).

TRUNCATULINA ROSTRATA, *Brady*.

*Truncatulina rostrata*, Brady, 1881, Quart. Journ. Micr. Sci. vol. xxi. n. s. p. 65.

*T. rostrata*, Brady, 1884, Rep. Chall. vol. ix. p. 668, pl. xciv. fig. 6 a-c.

The test of this species differs in having a peripheral slit-like aperture in addition to the normal truncatuline orifice. This form is restricted almost without exception to the coral islands of the Pacific.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 4 (23 fathoms); sample 14 (16 fathoms); sample 17 (12 fathoms); sample 18 (7½ fathoms).

TRUNCATULINA RETICULATA (*Czjzek*).

*Rotalina reticulata*, Czjzek, 1848, Haidinger's Naturw. Abhandl. vol. ii. p. 145, pl. xiii. figs. 7-9.

*Truncatulina* (*Rotalina*) *reticulata*, Czjzek, Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 402, pl. xvi. figs. 42-44.

*Planorbulina reticulata* (Czjzek), Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix. No. 1, p. 72.

*Truncatulina reticulata* (Czjzek), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 334, pl. 78. fig. 3.

This pretty little species is found in one sample only from the lagoon. The specimens are of normal size.

Lagoon, Funafuti. Sample 18 ( $7\frac{1}{2}$  fathoms).

#### ANOMALINA, *d'Orbigny* [1826].

##### ANOMALINA AMMONOIDES (*Reuss*).

*Rosalina ammonoides*, Reuss, 1845, Verstein. böhm. Kreide, pt. i. p. 36, pl. xiii. fig. 66, pl. viii. fig. 53.

*Anomalina* (*Rosalina*) *ammonoides*, Reuss, Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 378, pl. xiv. figs. 35-37.

*A. ammonoides* (Reuss), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 335, pl. 78. fig. 4.

This widely-distributed species is here represented by a small solitary specimen.

Lagoon, Funafuti. Sample 17 (12 fathoms).

#### CARPENTERIA, *Gray* [1858].

##### CARPENTERIA PROTEIFORMIS, *Goës*. (Pl. 19. fig. 11.)

*Carpenteria balaniformis*, var. *proteiformis*, Goës, 1882, K. Svenska Vet.-Akad. Handl. vol. xix. No. 4, p. 94, pl. vi. figs. 208-214, pl. vii. figs. 215-219.

*C. proteiformis*, Goës, Brady, 1884, Rep. Chall. vol. ix. p. 679, pl. xevii. figs. 8-14.

*C. proteiformis*, Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix. No. 1, p. 74, pl. vi. figs. 8-17.

Both examples found in the lagoon are attached to joints of *Halimeda*.

Lagoon, Funafuti. Sample 6 (21 fathoms); sample 7 (24 fathoms).

##### CARPENTERIA UTRICULARIS, *Carter*.

*Polytrema utriculare*, Carter, 1876, Ann. Mag. Nat. Hist. ser. 4, vol. xvii. p. 210, pl. xiii. figs. 11-16.

*Carpenteria utricularis*, Carter, 1877, Ann. Mag. Nat. Hist. ser. 4, vol. xx. p. 176.

*C. utricularis*, Carter, Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 438, pl. xxi. fig. 18.

*C. utricularis*, Carter, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 12, pl. 2. fig. 4, pl. 4. figs. 3, 4.

This species, like the preceding, appears to prefer the quieter areas of the lagoon. It was found attached to *Halimeda*.

Lagoon, Funafuti. Sample 10 (26 fathoms).

PULVINULINA, *Parker & Jones* [1862].PULVINULINA REPANDA (*Fichtel & Moll*).

*Nautilus repandus*, Fichtel & Moll, 1803, Test. Micr. p. 35, pl. iii. figs. a-d.

*Pulvinulina repanda* (F. & M.), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 405, pl. xviii. figs. 34-36.

*P. repanda* (F. & M.), Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix. no. 1, p. 75.

*P. repanda* (F. & M.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 328, pl. 72. fig. 8.

A full-sized specimen of the above occurred in the lagoon dredgings.

Lagoon, Funafuti. Sample 3 (20 fathoms).

PULVINULINA OBLONGA (*Williamson*).

*Rotalina oblonga*, Williamson, 1858, Rec. Foram. Gt. Brit. p. 51, pl. iv. figs. 98-100.

*Pulvinulina oblonga* (Williamson), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 415, pl. xvii. figs. 23-25.

The specimen found in the lagoon is a very delicate thin-shelled example. The 'Challenger' obtained it from the South Pacific in depths varying from 17 to 275 fathoms. It has a wide geographical distribution.

Lagoon, Funafuti. Sample 17 (12 fathoms).

ROTALIA, *Lamarck* [1804].ROTALIA BECCARII (*Linné*).

*Nautilus Beccarii*, Linné, 1767, Syst. Nat. 12th ed. p. 1162; 1788, ibid. 13th (Gmelin's) ed. p. 3370, no. 4.

*Rotalia Beccarii* (L.), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 420, pl. xix. figs. 25-27.

*R. Beccarii* (L.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 331, pl. 75. fig. 2.

This species is commonly found in temperate seas, but it is not confined to them. The specimens from the lagoon have the characteristic brown stain of the sarcode remaining with them, and have therefore probably lived where they were found.

Lagoon, Funafuti. Sample 1 (10 fathoms).

CALCARINA, *d'Orbigny* [1826].CALCARINA HISPIDA, *Brady*.

*Calcarina hispida*, Brady, 1876, Proc. R. Irish Acad. ser. 2, vol. ii. p. 590.

*C. calcar*, var. *hispida*, Carter, 1880, Ann. Mag. Nat. Hist. ser. 5, vol. v. p. 453.

*C. hispida*, Brady, 1884, Rep. Chall. vol. ix. p. 713, pl. cviii. figs. 8, 9.

This is one of the commonest of the smaller Foraminifera in the lagoon. From its low specific gravity and form it seems to be carried in large numbers to quite the centre of the lagoon. That it does not live there is evident from the fact that the specimens from samples taken at considerable distance from the lagoon shore are invariably stained of a muddy brown and are partially weathered or decomposed.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 2 (15½ fathoms); sample 4 (23 fathoms); sample 5 (24 fathoms); sample 6 (21 fathoms); sample 7 (24 fathoms); sample 8 (26 fathoms); sample 14 (16 fathoms); sample 15 (19 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms); sample 18 (7½ fathoms).

*CALCARINA DEFRANCI*, d'Orbigny.

*Calcarina Defranci*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 276, pl. xiii. figs. 5-7.

*C. Defranci*, d'Orb., Brady, 1884, Rep. Chall. vol. ix. p. 714, pl. cviii. fig. 6 a-c.

This generally rare form is found in one sample only in the lagoon.

Lagoon, Funafuti. Sample 1. (10 fathoms).

#### Subfamily TINOPORINÆ.

*TINOPORUS*, Montfort [1808], emend. Carpenter [1860].

*TINOPORUS BACULATUS*, Montfort.

*Tinoporus baculatus*, Montfort, 1808, Conchyl. Syst. vol. i. p. 146, 37<sup>e</sup> genre.

*T. baculatus*, Montf., Carpenter, 1860, Phil. Trans. p. 557, pls. xviii., xix.

*T. baculatus* [Montfort?], Carpenter, Brady, 1884, Rep. Chall. vol. ix. p. 716, pl. ci. figs. 4-7.

This species undoubtedly attains to its fullest development in the shallow waters of the South Pacific. At Funafuti it is remarkably abundant, and the beach-sand of the lagoon is largely composed of this species. It is rare, however, in the waters of the lagoon, and occurs in three samples only.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 11 (25 fathoms); sample 18 (7½ fathoms).

GYPSINA, *Carter* [1877].GYPSINA GLOBULUS (*Reuss*).

*Cerriopora globulus*, Reuss, 1847, Haidinger's Naturw. Abhandl. vol. ii. p. 33, pl. v. fig. 7.

*Gypsina globulus* (Reuss), Uhlig, 1886, Jahrb. geol. Reichsanst. vol. xxxvi. p. 197, figs. 7-9.

*G. globulus* (Reuss), Brady, Parker & Jones, 1888, Trans. Zool. Soc. vol. xii. p. 229, pl. xvi. fig. 13.

Some very fine examples of this species occur in the lagoon dredgings. They vary very much in size, the diameter of the test ranging from .5 mm. to 3.5 mm. The smallest specimens came from the middle of the lagoon.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 2 (15½ fathoms); sample 4 (23 fathoms); sample 6 (21 fathoms); sample 7 (24 fathoms); sample 11 (25 fathoms); sample 12 (25 fathoms); sample 13 (26 fathoms); sample 14 (16 fathoms); sample 18 (7½ fathoms).

GYPSINA INHÆRENS (*Schultze*).

*Acervulina inhærens*, Schultze, 1854, Organ. der Polythal. p. 68, pl. vi. fig. 12.

*Gypsina inhærens* (Schultze), Brady, 1884, Rep. Chall. vol. ix. p. 718, pl. cii. figs. 1-6.

*G. inhærens* (Schultze), Goës, 1894, K. Svenska Vetensk.-Akad. Handl. vol. xxv. No. 9, p. 91, pl. xv. fig. 787.

*G. inhærens* (Schultze), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 336, pl. 79. fig. 6.

The adherent forms of *Gypsina* are phenomenally numerous at Funafuti. To reduce the gradational series found there into something like order, and keeping in view some central type of structure, it seems convenient to group the more irregular and acervuline structured organisms under the name of *G. inhærens*, reserving the regularly discoidal forms as varieties of the mound-like *G. vesicularis*, from which they graduate down to thin scale-like forms.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 7 (24 fathoms); sample 13 (26 fathoms); sample 14 (16 fathoms); sample 15 (19 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms).

GYPSINA VESICULARIS (*Parker & Jones*). (Pl. 19. fig. 12.)

*Orbitolina vesicularis*, Parker & Jones, 1860, Ann. Mag. Nat. Hist. ser. 3, vol. vi. p. 31, no. 5.

*Gypsina vesicularis* (P. & J.), Carter, 1877, Ann. Mag. Nat. Hist. ser. 4, vol. xx. p. 173.

*G. vesicularis* (P. & J.), Egger, 1893, Abhandl. bayer. Ak. Wiss., math.-phys. Cl. ii. vol. xviii. p. 382, pl. xiv. figs. 20-23.

This species is usually found accompanying the spherical form *G. globulus*, into which it appears to graduate, but very rarely. On the other hand, it frequently shows affinities with the thinner varieties, by having a peripheral flange around the mound-like test.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 2 (15½ fathoms); sample 4 (23 fathoms); sample 5 (24 fathoms); sample 6 (21 fathoms); sample 8 (26 fathoms); sample 11 (25 fathoms); sample 13 (26 fathoms); sample 15 (19 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms); sample 18 (7½ fathoms).

*GYPSINA VESICULARIS* (P. & J.), var. *DISCUS*, Goës. (Pl. 19. fig. 13.)

*Tinoporos vesicularis* (P. & J.), Goës, 1882, Sv. Vet.-Akad. Handl. vol. xix. No. 4, p. 104, pl. vii. figs. 245-247.

*Gypsina vesicularis* (P. & J.), var. *discus*, Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix. No. 1, p. 74, pl. vii. figs. 4-6.

Upon this remarkable little variety Dr. Goës wrote as follows\* :—

“A variety closely allied to the type, from which it differs only in its lenticular shape and its more plainly differentiated set of the central cycle of chambers. It is not found affixed. Caribbean Sea, 400 fathoms; scarce.”

This is one of the most distinct varieties of the *G. vesicularis* type. The little button-shaped tests are usually depressed in the central region on both sides. It is noteworthy that this form was absent from the samples near the margin of the lagoon, appearing to prefer the quieter waters and at greater depths. This fact is further corroborated by Goës' record of its occurrence at 400 fathoms.

Lagoon, Funafuti. Sample 4 (23 fathoms); sample 5 (24 fathoms); sample 6 (21 fathoms); sample 7 (24 fathoms); sample 8 (26 fathoms); sample 10 (26 fathoms); sample 14 (16 fathoms); sample 15 (19 fathoms).

\* *Op. cit.* p. 74.



*GYPSINA VESICULARIS* (*P. & J.*), var. *MONTICULUS*, nov. (Pl. 19. figs. 14 *a*, *b*.)

Test attached, roughly discoidal; the attached surface flat or undulate, and showing the more regular central series of chambers, sometimes spiral, followed by the acervuline chambers; the free, superior surface sharply conical in the centre, rapidly sloping to the level of a thin peripheral flange. Distinguished from the thin wild-growing *Planorbulinae* by the absence of peripheral orifices and the entire absence of regularity in the peripheral chambers. Diameter ranging from 2 to 4 mm.

Lagoon, Funafuti. Sample 2 (15½ fathoms); sample 4 (23 fathoms); sample 5 (24 fathoms); sample 7 (24 fathoms); sample 8 (26 fathoms); sample 11 (25 fathoms); sample 13 (26 fathoms); sample 15 (19 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms).

*GYPSINA VESICULARIS* (*P. & J.*), var. *SQUAMIFORMIS*, nov. (Pl. 19. figs. 15 *a*, *b*.)

Test thin, normally attached, encrusting surfaces of organisms. Full-sized specimens measure about 3 or 4 mm. in diameter. Shell consists of a single layer of acervuline chambers. The paper-like fragments of the test of this variety are sometimes very numerous in the shallow-water sands, both within and outside the lagoon.

Lagoon, Funafuti. Sample 3 (20 fathoms); sample 4 (23 fathoms); sample 5 (24 fathoms); sample 7 (24 fathoms); sample 8 (26 fathoms); sample 13 (26 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms).

#### *POLYTREMA, Risso [1826].*

*POLYTREMA MINIACEUM* (*Pallas*).

*Millepora miniacea*, Pallas, 1766, Elenchus Zoophytorum, p. 251.

*P. miniaceum* (L.), Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix. No. 1, p. 75.

*P. miniaceum* (Pallas), Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 16, pl. 4. fig. 7.

This species is found living in the lagoon in some abundance, but it never attains to the size which it does outside the atoll, usually measuring only 2 mm. across. It is generally found attached to joints of *Halimeda*.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 6 (21

fathoms); sample 7 (24 fathoms); sample 10 (26 fathoms); sample 11 (25 fathoms); sample 13 (26 fathoms); sample 14 (16 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

*POLYTREMA MINIACEUM* (Pallas), var. *ALBA*, Carter.

*Polytrema miniaceum*, var. *album*, Carter, 1877, Ann. Mag. Nat. Hist. ser. 4, vol. xix. p. 213, pl. xiii. fig. 14.

This variety is generally rare at Funafuti.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 2 ( $15\frac{1}{2}$  fathoms); sample 7 (24 fathoms); sample 13 (26 fathoms).

*POLYTREMA PLANUM*, Carter. (Pl. 20. figs. 6, 7.)

*Polytrema planum*, Carter, 1876, Ann. Mag. Nat. Hist. ser. 4, vol. xvii. p. 211, pl. xiii. figs. 18, 19. [Immature growth.]

*Gypsina melobesioides*, Carter, 1877, *ibid.* ser. 4, vol. xx. p. 172. [Full-grown form, description only.]

*G. melobesioides*, Carter, 1880, *ibid.* ser. 5, vol. v. p. 445.

*Polytrema miniaceum* (Pallas), var. *involuta*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 17, pl. 2. fig. 3, and text-figure 2.

*P. planum*, Carter, Chapman, 1901, Ann. Mag. Nat. Hist. ser. 7, vol. vii. pp. 82, 83.

In my earlier description of the Funafuti specimens, this particular form was regarded as a variety of the common branching type of *P. miniaceum*, which is distinguished by its red colour. Since then I have found abundant specimens of *P. planum* of very extensive growth on rough reef-specimens from the same collection, which show that the affinities of *P. planum* are rather towards the white variety of *P. miniaceum*, var. *alba*, Carter; for in the fresh specimens its test is often of snowy whiteness, not unlike, as Carter remarks, the sugar-coating on a bride-cake. The cemented reef-specimens are often discoloured or yellowish in their tint, but never pink or rose-coloured.

It is exceedingly difficult in some cases to distinguish *P. planum* from certain encrusting plants such as *Lithothamnion* and *Lithophyllum*; and indeed the only distinctive character between *Lithophyllum onkodes* and *P. planum*, when viewed externally, is the presence of the little granular conceptacles often, but not always, to be seen studding the surface of the forms.

Carter's original description and figure dealt only with a young or immature growth, but a comparison between the type-specimen of the so-called *Gypsina melobesioides* at the Natural

History Museum, South Kensington, confirms the identity of the two forms.

This organism, as I have already shown, is of great importance as a rock-builder, by forming concentric encrustations round fragments of coral and algæ. It also plays an important part in cementing loose fragments together, by filling crevices and eventually enwrapping several fragments, until they form a solid conglomerate.

In the lagoon *P. planum* is found binding together the separate fronds of *Halimeda* as they lie on the lagoon-floor. It is impossible to distinguish *P. planum* in the lagoon material without the aid of thin sections made from the accreted fragments for microscopic examination.

Lagoon, Funafuti. Sample 6 (21 fathoms); sample 10 (26 fathoms); sample 11 (25 fathoms); sample 12 (23 fathoms); sample 14 (16 fathoms).

### Family NUMMULINIDÆ.

#### Subfamily POLYSTOMELLINÆ.

##### NONIONINA, *d'Orbigny* [1826].

##### NONIONINA DEPRESSULA (*Walker & Jacob*).

*Nautilus depressulus*, Walker & Jacob, 1798, Adams' Essays, Kammacher's ed., p. 641, pl. xiv. fig. 33.

*Nonionina depressula* (W. & J.), Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 427, pl. xix. figs. 38, 39.

This species is rare in the lagoon.

Lagoon, Funafuti. Sample 13 (26 fathoms): sample 18 (7½ fathoms).

##### NONIONINA UMBILICATULA (*Montagu*).

*Nautilus umbilicatus*, Montagu, 1803, Test. Brit. p. 191; Suppl. p. 78, pl. xviii. fig. 1.

*Nonionina umbilicatulula* (Montagu), Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 426, pl. xix. figs. 36, 37.

This species is more numerous than the preceding, and the specimens are as a rule typical.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 4 (23 fathoms); sample 7 (24 fathoms); sample 8 (26 fathoms); sample 11 (25 fathoms).

POLYSTOMELLA, *Lamarck* [1822].POLYSTOMELLA STRIATOPUNCTATA (*Fichtel & Moll*).

*Nautilus striatopunctatus*, Fichtel & Moll, 1798, Test. Micr. p. 61, pl. ix. figs. a-c.

*Polystomella striatopunctata* (F. & M.), Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 433, pl. xix. figs. 49, 50.

*P. striatopunctata* (F. & M.), Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix. No. 1, p. 78.

*P. striatopunctata* (F. & M.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 337, pl. 80. fig. 2.

The lagoon-specimens are neat and small.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 17 (12 fathoms).

POLYSTOMELLA MACELLA (*Fichtel & Moll*).

*Nautilus macellus*, var. *a*, Fichtel & Moll, 1798, Test. Micr. p. 66, pl. x. figs. e-g.

*Polystomella macella* (F. & M.), Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 432, pl. xx. figs. 22, 23.

The lagoon-specimens are rather small.

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 5 (24 fathoms); sample 16 (20 fathoms); sample 17 (12 fathoms); sample 18 ( $7\frac{1}{2}$  fathoms).

POLYSTOMELLA CRISPA (*Linné*).

*Nautilus crispus*, Linné, 1758, Syst. Nat. 10th ed. p. 709.

*Polystomella crisa* (L.), Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 432, pl. xx. figs. 20, 21.

*P. crisa* (L.), Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 338, pl. 80. fig. 3.

This occurs very sparingly in the lagoon.

Lagoon, Funafuti. Sample 2 ( $15\frac{1}{2}$  fathoms); sample 4 (23 fathoms); sample 17 (12 fathoms).

POLYSTOMELLA SUBNODOSA (*Münster*).

*Robulina subnodosa*, Münster, 1838, Neues Jahrb. für Min. p. 391, pl. iii. fig. 61.

*Polystomella subnodosa* (Münster), Reuss, 1855, Sitzungsab. Ak. Wiss. Wien, vol. xviii. p. 240, pl. iv. fig. 51 a, b.

*P. subnodosa* (Münster), Brady, 1884, Rep. Chall. vol. ix. p. 734, pl. cx. fig. 1 a, b.

*P. subnodosa* (Münster), Goës, 1894, Kongl. Sv. Vet.-Akad. Handl. vol. xxv. No. 9, p. 102, pl. xvii. figs. 817-819.

The specimens from Funafuti agree in most respects with those figured by Goës from Novaya Zemlaia and off Newfoundland. By a comparison of the chief characters of the tests of this species and *P. striatopunctata*, there seems to be a direct affinity between those forms; and it is possible that they represent a single species, of which *P. subnodosa* is the megalo-spheric type, with an umbonate centre, and *P. striatopunctata* the microspheric type, with a depressed centre.

*P. subnodosa*, as a recent form, has been but rarely found up to the present, for, besides the localities mentioned above, it has only been found amongst the islands south-west of Papua, at depths of from 6 to 28 fathoms.

Lagoon, Funafuti. Sample 18 (7½ fathoms).

#### Subfamily NUMMULITINÆ.

##### AMPHISTEGINA, d'Orbigny [1826].

##### AMPHISTEGINA LESSONII, d'Orbigny.

*Amphistegina Lessonii*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 304, No. 3, pl. xvii. figs. 1-4: Modèle No. 98.

*A. Lessonii*, d'Orb., Möbius, Beitr. Meeresfauna Insel Mauritius, p. 99, pl. x. figs. 10-14, pl. xi. figs. 1-3.

*A. Lessonii*, d'Orb., Flint, 1899, Rep. U.S. Nat. Mus., Rep. for 1897, p. 338, pl. 80. fig. 4.

This is the only species of Foraminifera which was obtained from every sample of the lagoon dredgings. It varies in size from a diameter of .75 to 3.5 mm. The test is often flexuose on the peripheral edge; and towards the middle of the lagoon it shows a tendency to make abnormal outgrowths, in beak-like processes near the last series of chambers in adult shells, or as buds around the oral aperture. The test sometimes shows a tendency to become partially attached to algæ, at the oral region, especially in the deeper parts of the lagoon.

Lagoon, Funafuti. In samples 1 to 18. Samples 4, 6, and 15 yielded the finest specimens.

HETEROSTEGINA, *d'Orbigny* [1826].HETEROSTEGINA DEPRESSA, *d'Orbigny*.

*Heterostegina depressa*, d'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 305, pl. xvii. figs. 5-7 : Modèle No. 99.

*H. curva*, Möbius, 1880, Beitr. Meeresfauna Insel Mauritius, p. 105, pl. xiii. figs. 1-6.

*H. depressa*, d'Orb., Egger, 1893, Abhandl. bayer. Akad. Wiss., math.-phys. Cl. ii. vol. xviii. p. 433, pl. xx. figs. 34, 35.

*H. depressa*, d'Orb., Goës, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix. No. 1, p. 79.

*H. depressa*, d'Orb., Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 18, pl. 3. figs. 6, 7.

This species is well represented in the lagoon samples, but it does not occur in a few from near the middle of the lagoon.

*H. depressa* here ranges from 75 mm. to 9 mm. in diameter. No specimens of the form B (microspheric) occur in the samples.

The largest specimens occur in sample 8 (26 fathoms).

Lagoon, Funafuti. Sample 1 (10 fathoms); sample 2 (15½ fathoms); sample 3 (20 fathoms); sample 4 (23 fathoms); sample 5 (24 fathoms); sample 6 (21 fathoms); sample 7 (24 fathoms); sample 8 (26 fathoms); sample 9 (25 fathoms); sample 10 (26 fathoms); sample 14 (16 fathoms); sample 15 (19 fathoms); sample 17 (12 fathoms); sample 18 (7½ fathoms).

In the annexed synopsis of species from the Funafuti Lagoon the following significations are used:—v.r.=very rare, r.=rare, f.=frequent, c.=common, v.c.=very common. These indications are printed in three kinds of type: capitals (V.C.) signifying the specimens are well developed or extra large; ordinary type (v.c.) that the specimens are of normal size; and italics (*v.c.*) that the specimens are starved or of diminutive size.









[illegible]

112. *Orbitolites complanata*, Lam., var. *plicata*, J. D. Dana (= *lacinata*, Brady), occurs abundantly in the sand of the lagoon beach at Funafuti.

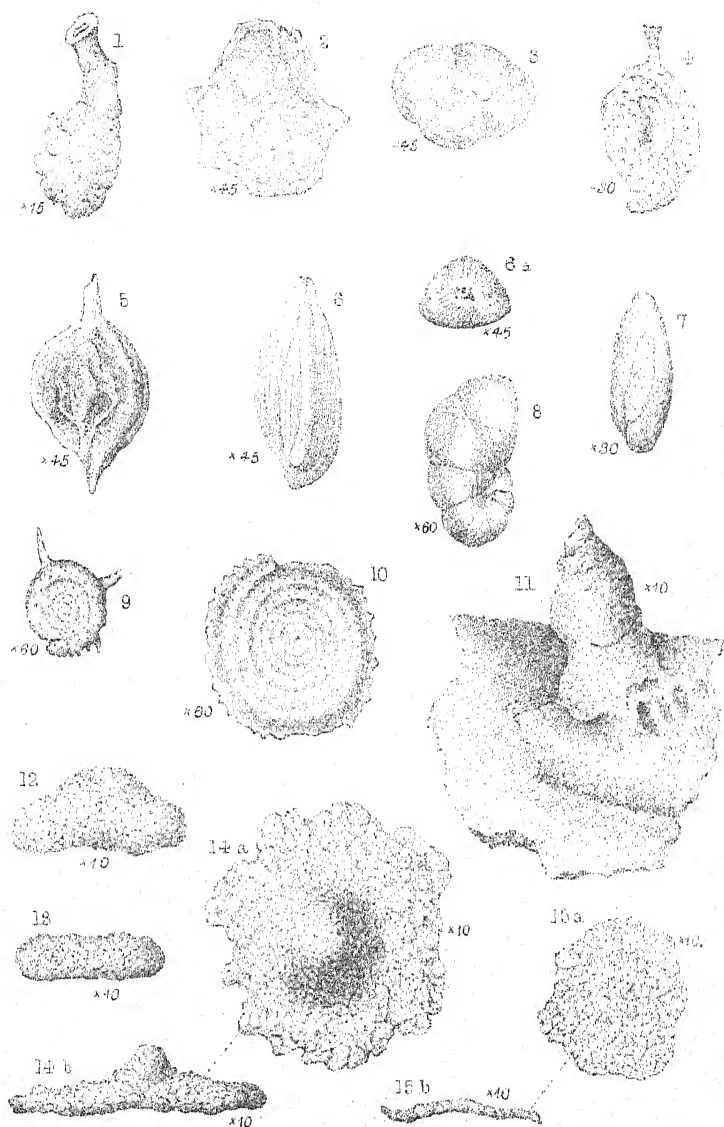
## EXPLANATION OF THE PLATES.

## PLATE 19.

- Fig. 1. *Nubecularia divaricata*, Brady. Lagoon, Funafuti, No. 18.  $\times 15$ .  
 2. " *lacunensis*, sp. nov. Lagoon, Funafuti, No. 18.  $\times 45$ .  
 3. " *Bradyi*, Millett. Lagoon, Funafuti, No. 18.  $\times 45$ .  
 4. *Spiroloculina nitida*, d'Orb., var. *foveolata*, Egger. Lagoon, Funafuti, No. 18.  $\times 30$ .  
 5. *S. tortuosa*, sp. nov. Lagoon, Funafuti, No. 5.  $\times 45$ .  
 6. *Miliolina Funafutiensis*, sp. nov. Lagoon, Funafuti, No. 17. 6 a, oral aspect.  $\times 45$ .  
 7. *M. Bosciana* (d'Orb.). Lagoon, Funafuti, No. 17.  $\times 30$ .  
 8. *Peneroplis* (*Monalysidium*) *politus*?, Chapman. Lagoon, Funafuti, No. 18.  $\times 60$ .  
 9. *Spirillina spinigera*, Chapman. Form A. Lagoon, Funafuti, No. 18.  $\times 60$ .  
 10. *S. spinigera*, Chapman. Form B. Lagoon, Funafuti, No. 18.  $\times 60$ .  
 11. *Carpenteria proteiformis*, Goës. Lagoon, Funafuti, No. 6.  $\times 10$ .  
 12. *Gypsina vesicularis* (Parker & Jones). Lateral aspect. Lagoon, Funafuti, No. 8.  $\times 10$ .  
 13. *G. vesicularis*, var. *discus*, Goës. Edge view. Lagoon, Funafuti, No. 15.  $\times 10$ .  
 14 a, b. *G. vesicularis*, var. *monticulus*, nov. a, superior aspect; b, side view. Lagoon, Funafuti, No. 8.  $\times 10$ .  
 15 a, b. *G. vesicularis*, var. *squamiformis*, nov. a, superior aspect; b, edge view. Lagoon, Funafuti, No. 8.  $\times 10$ .

## PLATE 20.

- Fig. 1. *Orbitolites marginalis* (Lam.). Specimen found attached to a joint of *Halimeda*. Lagoon, Funafuti, No. 17.  $\times 14$ .  
 2. *O. marginalis* (Lam.). A radially-marked specimen, probably due to the form of the object upon which it rested. Lagoon, Funafuti, No. 17.  $\times 14$ .  
 3. *O. marginalis* (Lam.). A specimen with secondary thickening of the test arranged radially; a parallel case with *O. complanata*, var. *plicata*, Dana.  
 4. *Planorbulina acervalis*, Brady, var. *fimbriata*, nov. Lagoon, Funafuti, No. 8.  $\times 20$ .  
 5. *P. larvata*, Parker & Jones, var. *crispata*, nov. Lagoon, Funafuti.  $\times 14$ .  
 Figs. 6, 7. *Polytrema planum*, Carter. Sections of the organism encrusting *Halimeda*-joints. Lagoon, Funafuti.  $\times 14$ .



F. Chapman. ad. nat. del.  
A. Hammond lith.

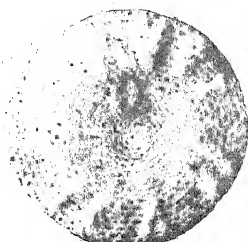
West, Newman imp.

FORAMINIFERA FROM THE LAGOON, PUNAFUTI.

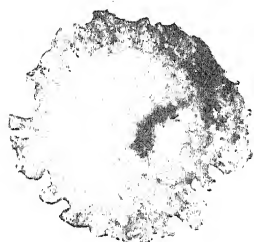




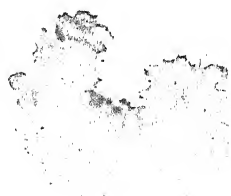
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3 x 17



4 x 20



5 x 14

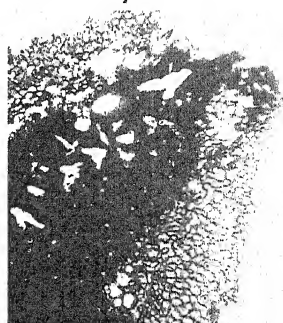


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6



7



F. C. Photonier.

FORAMINIFERA FROM FUNAFUTI.



*Goidelia japonica*—a New Entozoic Copepod from Japan, associated with an Infusorian (*Trichodina*). By ALICE L. EMBLETON, B.Sc. (Communicated by Prof. G. B. HOWES, Sec. Linn. Soc.)

[Read 15th November, 1900.]

(PLATES 21 & 22.)

WHILE working last spring in one of the Laboratories of the Royal College of Science, London, on the structure of *Echiurus uncinatus* \*, an almost unknown Japanese Gephyrean obtained for me by Professor G. B. Howes, my attention was arrested by the constant occurrence of a parasitic Copepod in the rectum: it was always present in great numbers, along with an Entozoic Protozoan which, so far as I can determine from preserved material, is a new species of *Trichodina* (Pl. 22. fig. 20, i., ii., iii. —see note *infra*, pp. 227–8). Though this soft-bodied unicellular creature was not sufficiently well preserved to give satisfactory results as to its detailed structure, the Copepod was in good condition. In my work upon this parasite I have been greatly assisted by Mr. M. F. Woodward, whose suggestions and advice have been most valuable. The microscopic size and extreme brittleness of the animal rendered dissection difficult, and necessitated the use of many different stains and reagents. I am especially indebted to Mr. Woodward for his experienced aid in the micro-chemical part of the manipulation.

On opening the rectum of the host, large numbers of the parasite are seen free in the contained fluid; many of them, however, are invariably attached to the epithelial lining of the rectum. On trying to remove these it is found that they are adhering very firmly, the anterior end being more or less embedded in the host's tissue; and after they have been detached (with a moderately stiff camel's-hair brush) little crypts, or scars, remain showing the places where the parasites had been situated.

The length of the body—without the caudal setæ—is about .5 mm. to .7 mm. Pl. 21. fig. 1 is a scale-drawing of an adult female (A), an adult male (B), and an immature female (C); it is a *camera-lucida* drawing, in which the specimens were magnified

\* Trans. Linn. Soc., Zool. ser. 2, vol. viii. part 3.



to the same extent as the millimetre-scale, where the ultimate divisions are tenths. In this way I have been able to get accurate measurements of the various parts of the body, from which some interesting comparative results were obtained.

Further investigation showed this Copepod to be an entirely new form; and this opinion was confirmed by Dr. Brady, to whom some specimens were submitted. I propose to name it *Goidelia japonica*.

After carefully examining many individuals, and comparing them with descriptions of parasitic and semi-parasitic Copepods, I find they most resemble the *Hersiliidae*, as described by Claus\*, Canu†, and Kossmann‡. The affinities of this family are still uncertain, and, though *Goidelia japonica* is apparently related to this group, yet it is more truly endo-parasitic than either of the three known genera which have so far made up the family. But apart from the difficulty arising out of the unsettled condition of the affinities of this family, I find that its name, *Hersiliidae*, is already occupied by a well-known family of Spiders, possessing also the genus *Hersilia*; there is, moreover, a genus *Hersilia* in the Coleoptera and also in the Diptera. On looking up the literature on these four different groups, it is clear the name belongs—by right of priority—to the Arachnida: as the spider *Hersilia* (Audouin) appears in 1825–27 in Savigny's 'Description de l'Égypte.'§ The next to receive the name was the beetle of the family *Chrysomelinae*, which was christened in 1834 by Dejean||. It was not until November 2nd, 1839, that Dr. A. Philippi¶ found the Crustacean, which he called *Hersilia apodiformis*, describing it as "Ein neues Genus der Entomostraccen." Some years later, that, in 1863, Robineau-Desvoidy again used

\* "Neue Beiträge zur Kenntniss parasitischer Copepoden, nebst Bemerkungen über das System derselben." Zeitschr. f. wiss. Zool. xxv., 1875.

† "Les Copépodes Marins du Boulonnais": iii. "Les *Hersiliidae*, famille nouvelle de Copépodes commensaux." Bull. Sci. Nord France et Belg. tom. 19, 1888.

‡ "Ueber *Clausidium testudo*, einen neuen Copepoden, nebst Bemerkungen über das System der halb-parasitischer Copepoden." Verhandl. phys.-med. Gesell. in Würzburg, vii., Neue Folge, 1874.

§ "*Hersilia* (Audouin)" in Savigny, Descrip. Égypte (2nd ed.), xxii. 1825–27, p. 317. E. Simon, Hist. Nat. Araignées (2nd ed.), vol. i. p. 446.

|| "*Hersilia* (Dejean)," Catal. Coleop. (2nd ed.), 1834: *Chrysomelinae*.

¶ "Einige zoologische Notizen." Archiv für Naturgeschichte (Wiegmann), Band v. 1, 1839.

the name for a new genus of *Muscidae*, in the group of Diptera\*. Then, in 1874, Dr. R. Kossmann published his account of the Copepod *Hersilia* under the name of *Clausidium testudo*. In 1886 Professor Heller met with it in the branchial cavity of *Callianassa*. Since then several other authors have investigated the parasite under the name *Hersilia*, with the result that the family name, in 1888, became *Hersiliidae*. The consequence is that there exist four genera with the same name, two of which give the name to the family *Hersiliidae*. Such an occurrence is always the source of much confusion; but in this case the possibility of error is increased by the fact that they are all Arthropoda. To avoid any further misunderstanding, I have been advised by Dr. D. Sharp and Mr. C. Warburton, of Cambridge, to entirely remove the names "*Hersiliidae*" and "*Hersilia*" from the order Copepoda. I propose, therefore, to substitute for *Hersiliidae* the family name *Clausidiidae*, and for *Hersilia* the generic name *Clausidium* as proposed and used by Kossmann in 1874. It seems best to thus adopt the name used by Kossmann, instead of introducing a new one, as I had at first intended to do. I shall use these names throughout the paper, except of course where I quote other writers, in which case I shall give those used by them.

In spite of the fact that several authors have paid special attention to it, the genus "*Hersilia*" is still looked upon as aberrant, and the opinions as to its affinities differ widely. Kossmann, as we see, calls it *Clausidium*, and claims for it relationship with the Siphonostomes—*Artotrogus* and *Asterocheres*. Others ally it to the *Peltidiidae*. Claus and Heller claim (and, so far as I can judge, are justified in so doing) that the "*Hersiliidae*" are a family of Copepods, distinct alike from the *Siphonostomidae* and from the *Peltidiidae*; while Milne-Edwards† admits the difficulty in classifying them. He says they seem to have some analogy with the *Sapphirinidae* and *Peltidiidae*, but that they also approach the *Argulidae* in the general form of the body; our knowledge of them being so incomplete, he is unable to determine with certainty their place in the natural system of classification.

\* "*Hersilia* (Robineau-Desvoidy)," Hist. Nat. Diptères Env. Paris, i. p. 499, 1863: *Muscidae*.

† Hist. Nat. Crust. iii., 1840.

For purposes of comparison, bearing on the systematic position of *Goidelia japonica*, it may be as well to give the features characteristic of the whole family, as stated by Canu :—

"Body completely segmented; first thoracic segment joined to the cephalic ring; first antenna composed of seven segments, being the same in both sexes; second antenna simple, with four joints; mandibles devoid of a palp, and without masticatory teeth, but provided distally with accessory mobile parts in the shape of a solid bent claw, or rather of flat blades with regular denticles and serrations, or of hooks finely fringed; maxillary rudimentary, showing, however, traces of a division into a masticatory lobe (internal) and a palp (external); maxillipedes well-developed, the first furnish important sexual distinctions; thoracic feet biramous, and the rami of three joints in the four anterior pairs, simple and flat in the fifth pair."

The family is, according to Canu, made up of the three genera *Hersilia*, *Hersiliodes*, and *Giardella*; of these, he says, *Hersilia* is commensal more intimately—*i. e.* more nearly approaches an entozoic condition—than the other two genera. The classification is based on the differences in the mouth-parts, special significance being attached to the accessory parts at the distal end of the mandibles, as is seen by the following table given by Canu :—

"Table of Genera.—Mandibles bearing at their distal extremity besides the recurved claw common to all the family :—

i. *Two accessory pieces.*

1. The anterior is a flat serrated blade, and the posterior is a small bearded hook. In the male, the 1st maxillipede is formed of two joints, the end being chelate, reduced and toothed.

Genus *Hersilia* (Philippi).

2. Almost the same, with flat, toothed, triangular blades laterally. In the male, the 1st maxillipede has two basal joints, and a well-developed prehensile end in the form of a long recurved claw.

Genus *Giardella* (Canu).

ii. *Three accessory pieces.*

3. The anterior is a subtriangular, toothed blade, and the others are two long bearded flexible hooks. Genus *Hersiliodes* (Canu)."

The distinguishing features of the three genera, as given by Canu, are as follows :—

"Genus *Hersilia* (Philippi).—Body flattened, composed of very distinct segments, male with ten, female with nine (not counting the furcæ); first antenna seven-jointed; second antenna simple, four-jointed; cutting-mandible relatively small, bearing at its distal end three accessory pieces

in the form of a claw, a toothed plate, and a hook; maxillæ rudimentary and of the form common to all three genera; first maxillipede same in female and male, and made up of (i.) in female three parts (and not as Claus says four), all bearing long hooks, often bearded; (ii.) in male, two parts, basal well-developed, and a terminal joint reduced to a short prehensile spine; first pair of thoracic feet very different from the three following which are alike, and transformed into organs of adhesion; second, third, and fourth thoracic somites formed of three basal parts, and of two rami each with three joints; fifth pair simple, two-jointed, and flat."

"Genus *Giardella* (Canu).—Body flattened, 'cyclopoid,' and of distinct segments, male and female with ten; first antenna seven-jointed; second antenna four-jointed; mandibles large, bearing at their distal ends as accessory pieces a claw and two large bearded hooks; first maxillipede different in the two sexes and made up (1) in female of three parts carrying bearded hooks; (2) in male, a basal joint carrying two bearded hooks, a median long and enlarged joint, toothed on its inner edge, and armed with two hooks on its interior surface; finally a terminal joint in the form of a spine, recurved at its tip, and almost as long as the rest of the appendage. Thoracic feet of four first pairs of normal form, biramous with three joints; fifth simple, two-jointed and flat."

"Genus *Hersiliodes* (Canu).—Body slightly flattened, rather elongated, and composed of distinct segments; first antenna seven-jointed; second antenna four-jointed; mandibles rather large, with four accessory pieces (a claw, a toothed blade, two long flexible bearded setæ); thoracic feet of fifth pair simple, two-jointed and flat."

On comparing *Goidelia japonica* with these descriptions, it is at once evident that the agreement is not sufficient to justify me in placing it in either of these genera, differing as it does from all three in many fundamental points. This may be due largely to its very different mode of life, for these three known genera are ecto-parasites, or merely commensals, whereas this creature is truly entozoic. It may be that its host, *Echiurus uncinatus*, has anal respiration\*, in which case there would be a current of water flowing continuously in and out of the rectum, rendering the life of the parasite there far less accurately endo-parasitic than would be the case in the more anterior tracts of the alimentary canal. However, it is not at all certain that such a process of anal respiration takes place; so the life of the Copepod may be looked upon as typically entozoic.

According to Kossmann, Philippi, Claus, and Canu, the female and male of *Clausidium* not only differ in size, but the male is

\* See paper in the Trans. Linn. Soc. already referred to.

attached to the abdomen of the female. Kossmann says the female is 1.7 mm. and the male 0.6 mm. in length. Claus repeats Philippi's measurements of  $\frac{2}{3}$  line for the female, the male being but half as long. In this new Japanese form, however, the sexes show little (if any) difference in size, and I have found no single instance of the male being attached to the female. Sexual dimorphism between the female and male is not very apparent, only being manifest on a closer examination of the more minute parts; none of the adult females have egg-sacs, as these would doubtless only be present for a very short period, which may explain their absence from my specimens if they were collected at a time of year when the sacs are not developed. Thus, a general description of the animal applies equally to the two sexes.

The body is flattened dorso-ventrally, the carapace being, however, slightly arched above. Dorsally, the outlines of the segments are quite clear, there being four well-marked thoracic segments behind the head; following on this is the small tapering abdomen made up of 6 segments, the last two of which are divided and constitute the furcæ, each limb carrying an inner long and an outer short seta (Pl. 21. figs. 1, 2, 3, 4). In the adult female the first three abdominal segments are fused, and in this fused region the paired genital pores open ventrally (Pl. 21. fig. 2, *g.*).

There are no eyes, which may be an adaptation to its habitat. Canu figures *Hersiliodes* as being destitute of eyes, though the other two genera possess them paired and well-developed.

Anteriorly the carapace curves down, as is seen on looking at the creature from below (Pl. 21. figs. 2, 3). Notches in this in-turned edge occur to allow for the free movement of the first antennæ, between the bases of which the carapace bears at its edge two short spines (not, however, in the adult male, though present in its earlier stages).

In order to investigate the appendages, it was necessary to get separate dissections of each. The animal being so small and its chitinous parts being so brittle, I experienced considerable difficulty in obtaining satisfactory preparations. The best results were secured when I boiled the material in strong potash for some minutes, washing it thoroughly in water before staining with safranin. Specimens treated in this way showed most of the hard parts with great clearness, though the safranin being an aniline dye, fades in glycerine, with the result that the mountings

are not permanent. To obviate this difficulty borax-carmin, or Ehrlich's hæmatoxylin, can be utilized instead.

In addition to the adults of both sexes, I succeeded in detecting earlier stages in which certain of the appendages exhibit striking modifications; other appendages, however, are alike in both sexes and in all stages. Those that are constant are:—

- i., the first antenna;
- ii., the second antenna;
- iii., the mandibles;
- iv., the maxillæ;
- v., vi., vii., viii., the first four thoracic legs—the fifth seems to be much bigger in the adult female than in the adult male, though similar in other respects.

*First Antenna.*—Alike in all stages and both sexes; it is composed of five segments, bearing numerous setæ; the first is the longest and largest segment, the remaining four gradually diminishing and tapering to the end (Pl. 22. fig. 5).

In all published accounts of the family this appendage is described as having seven segments, in fact Canu gives that as one of the family features; however, he figures the first and second Copepod stages of *Hersiliodes* and *Giardella* as having but five joints.

*Second Antenna.*—Alike in all stages and both sexes. It consists of four segments, the first being the largest, the other three being bent back on this basal joint, forming a conspicuous and characteristic elbow; this elbow of each antenna approaches the other in the middle line above the upper lip (Pl. 22. figs. 6, 7), and is seen very clearly on the ventral surface; it is characteristic of the three genera described by Canu. On the inner edge of the distal end of the first segment there are two small spines and one long feathered seta (figs. 6, 7); the second joint is small and, so far as I can make out, carries no process at all; the third has on its outer surface two setæ, one being feathered and much longer than the other. All the complex hooking apparatus is confined to the fourth and smallest factor of the appendage. This apparatus is built up of five prehensile claws or processes: the first, and smallest, is a short stout organ with its inner face toothed near the extremity (figs. 6, 7); the next process is similar to this, only slightly longer; the third differs only in the fact that it is more slender; the fourth has a long, slightly curved, smooth portion which abruptly passes over into a

smaller part ending in three teeth on its inner surface; the fifth is the same, being however longer and stouter (Pl. 22. figs. 6, 7).

In none of the descriptions of allied forms can I find an account of such an apparatus as this on the second antenna, though the number of parts going to make up the limb agrees with that in other genera, but this hooking arrangement is peculiar to *Goidelia japonica*. Doubtless these hooks serve to fix the parasite to the walls of the rectum of its host.

*Mouth-parts*.—These consist of an upper lip, mandibles, and maxillæ, all grouped on a raised dome-shaped area, occupying a relatively small space, owing to the reduction and degeneration of the various parts (Pl. 21. figs. 2, 3, *mv.*).

*Upper Lip*.—Overhanging the mouth-opening is a flattened lip; its lower edge is not pointed into a "beak" as Kossmann says of *Clausidium*:—"die Oberlippe läuft nach hinten zu in einen spitzen Schnabel aus, und erinnert insofern an die Rüsselbildung der verwandten Copepoden." Claus, however, speaking of the same creature says:—"Der breite Oberlippe bleibt von der zweilappigen mit feinen spitzen überkleideten Unterlippe vollkommen getrennt, kann die letztere aber beim Weibchen bedecken. Eine dem Rüssel von Parasiten vergleichbare Schnabelbildung vernassen wir durchaus." In Claus' fig. 3, the lip appears very similar to that in my specimens. The double-lobed lower lip he mentions is present, fringed with fine setæ. The upper lip forms a sort of flap, alike in female and male, its lower edge being slightly curved (Pl. 22. fig. 10, *lv.*), with a line of fine setæ just above the free edge. In the male this lip bears stronger and more numerous setæ, being particularly well-developed at the side angles of the lip. Beneath it, and just above the lower lip, is the small, almost circular, mouth-opening. The upper lip almost completely covers the mandibles, which are very small and simple.

*Mandibles*.—These are a pair of very small chitinous structures of simple organization. Each mandible is a slightly curved claw-like organ, ending in a serrated hook (Pl. 22. figs. 8, 9, 10, *md.*), the lower edge of which is toothed; this claw articulates on to the main stem of the mandible. The mandible of each side approaches the other in the middle line, not sloping to each other in an accurately transverse direction, but both pointing a little posteriorly. There are no "accessory pieces" or palps on this simple organ, though Canu, in all the three known genera,

gives two or three additional plates or processes. The form of the mandible in *Goidelia japonica* is constant for the adult and immature stages of both sexes. Canu also finds that the mouth-parts of the *Clausidiida* are not altered by the various moults. Claus, in *Clausidium*, depicts the mandible with this claw-shaped end-piece, but in this case there is, in addition, a fringed process beneath it, entirely absent in *Goidelia japonica*. Therefore, by taking the mouth-parts as the basis for classification, it becomes necessary (on this point alone) to separate this new form from the other three genera, though it is undoubtedly related to the group, in spite of its entozoic mode of life, which has made its structure much more modified than these less parasitic forms. These three known genera, Canu asserts, form, in respect to degrees of parasitism, a series: in such a series *Goidelia japonica* would have to be placed at the one end as being the most parasitic.

*Maxillæ*.—Alike in all stages and both sexes. They are greatly reduced, being merely small oval organs (fig. 10, *mw.*), unsegmented, and perfectly simple except for the fact that they possess three feathered setæ. They are situated behind the mandibles, but are not covered by the lips; their insertion is on a level with the base of the mandibles, and, so far as it is possible to judge from preserved specimens, they seem incapable of movement as a whole, though doubtless the setose processes function instead. The maxillæ here agree very closely with the descriptions given by Canu in *Hersiliodes* and *Giardella*, though they are smaller and more simple in *Goidelia* and have fewer processes. Canu says that in the above two genera traces can be seen of a division into a masticatory internal lobe, and a palp-like external lobe—quite absent in my specimens, however. Kossmann describes the maxilla of his *Clausidium* as “eine fast rehgeweihformige Maxille,” and from his fig. 6 the organ has indeed almost the appearance of a stag’s horns; he figures only three setæ, as also does Claus for the maxilla of the same form: these two figures agree in all other respects with mine.

*First Maxillipede* ♀.—This appendage differs strikingly in the various stages of development; I have been able to distinguish four very sharply defined stages in the female:—

A.—The youngest and least differentiated condition, in which the appendage is scarcely more than a flattened disc or plate, bearing a fringe of short setæ. A rudimentary palp can just be



discerned (Pl. 22. fig. 11, *p*), though in this stage it has not yet developed its two setæ.

B.—The organ at this stage is larger and more modified, it ends in a strong recurved hook (figs. 12, 13); its lower edge is fringed with setæ, and about a third of the way along this border is another spine, almost as strong as the terminal one. Laterally, on the inner surface, there is a palp (figs. 12, 13, *p*), the rudiment of which was seen in stage A, but now it bears two long terminal setæ; this palp is apparently a moveable organ and serves as a brush.

C.—This is a very interesting stage, for one can make out *within* the chitin of the maxillipede two folded hooks; the terminal spine and setæ of stage B remain, but the palp is not always present at this stage. It is obvious that the two immature enclosed hooks belong to the new appendage, and that they will unfold at the next moult when the old chitinous coat is shed (fig. 14).

D.—This is the largest and final stage in the development of this appendage. All sign of setose fringing is gone along with the palp (fig. 15). It is now a clearly-outlined claw-like organ, ending in a powerful recurved tip, directed backwards; along the posterior surface is a second, stout, hooked process. It is probable that this organ is prehensile, and helps to fix the parasite securely to its host.

*First Maxillipede* ♂.—I find this limb is unaltered in all the stages in the male, except that in its very early stages it has setæ on its surface as well as on its edge. It is a flattened petaloid plate of chitin, having its free border fringed with fine setæ (Pl. 22. fig. 16); and is evidently greatly reduced, for it resembles the first and very undifferentiated form which this appendage has in the stage A of the female. The first is applied closely to the highly-specialized second maxillipede, from which, however, it can be detached by careful dissection of a specimen boiled in potash. Judging from the three known genera, I had expected to find this appendage highly developed in the male, as it is in all the three allied forms, where, however, it is alike in the two sexes, being a short solid organ with two joints and armed with hooks and setæ. That it should be so degenerate in *Goidelia* in the male is a very remarkable fact, and serves to distinguish this from any other form.

*Second Maxillipede* ♀.—This is very feebly developed in all

the stages, being merely a papilla with but slight elevation above the surface. Relatively to the mouth-parts it is situated somewhat postero-laterally (Pl. 21. fig. 2, *mp.*<sup>2</sup>), and is less conspicuous in specimens boiled in potash than in those which have been treated with borax-carmines (or alum-carmines), and cleared in oil of cloves.

According to other authors, the second maxillipede is a very important appendage in *Clausidium*, *Hersiliodes*, and *Giardella*, and, unlike the first maxillipede, it differs in these genera in the female and male. In *Clausidium* female, Canu says it has three parts (Claus describes four), bearing setæ; in the male it has two well-marked basal joints and a terminal factor in the form of a short prehensile hook. In the female of *Giardella* it is as in *Clausidium*; but in the male of *Giardella* and *Hersiliodes* there is one basal joint with two feathered setæ, a median long joint with teeth on its inner ridge and two setæ on its internal face; finally there is a terminal segment in the form of a spine recurved towards the end and almost as long as the rest of the maxillipede.

Speaking of the family as a whole, Canu remarks:—"Maxillipèdes bien développés: les internes fournissant d'importantes différences sexuelles." I cannot help thinking that Canu has named the two pairs of maxillipèdes erroneously. Those which Claus calls "vordere" and "hintere," I call respectively "first" and "second." Canu uses the terms "interne" and "externe," yet his description and figure of the pair designated "interne" coincide with the "hintere" of Claus and my "second"; by "externe," therefore, we must conclude he refers to the "vordere" (or "obere") or first maxillipede, which he says is alike in both sexes. In *Goidelia japonica*, however, neither the first nor the second maxillipèdes are alike in the female and male: the first maxillipede is highly specialized in the female and small and unimportant in the male; the second maxillipede being, conversely, important in the male and inconspicuous in the female.

These appendages seem to offer peculiar difficulties, for Kossmann has mistaken the first maxillipede for a second maxilla, concerning which Claus observes:—"In Wahrheit aber ist Kossmann's zweite Maxille der obere Maxillarfuss, und die als Maxillarfuss beschriebene Gliedmasse der Kieferfuss des zweites Paares. Der obere Kieferfuss schliesst sich nach Form, Lager und Gebrauch am nächsten an die gleichwerthigen Gliedmassen der *Corycæiden* (*Copilia*, *Sapphirina*) an, und führt in weitere

Reduction zu den entsprechenden Maxillarfüssen der *Ergasiliden*. Ich vermag nur zwei Abschnitte zu unterscheiden ein mit mehreren Fiederborsten besetztes, in Stiletborsten wie gabelig gespaltenes Endglied, und ein umfangreiches Staumglied, dessen Innenseite noch am oberen Ende einen breiten mit starker Borste bewaffneten Fortsatz entsendet. Der untere Maxillarfuss bewahrt eine vollständigere Gliederung, die sich auch an den gleichwerthigen Gliedmassen der *Corycaiden* erhält, nähert sich aber in weiblichen Geschlechte mehr den bei *Cyclopiden* (*Cyclops*, *Oithina*) beobachteten Formverhältnissen. Auf zwei lauggestreckten je zwei Fiederborsten tragenden Staumgliedern, welche knieförmig gegeneinander gebent werden, folgen zwei kurze Endglieder, von denen das obere sehr starke wenn auch kaum gekrümmte Borsten trägt. Die sexuelle Umformung der männlichen Kieferfüsse, die schon bei *Corycaiden*, ferner bei *Bomolchus* und Verwandten sehr augenfällig ist, führt in unserem Falle zur Ausbildung eines sehr eigenthümlichen Klammerapparates, welches mit der bereits besprochenen Umformung des weiblichen Abdomens in Correlation steht und die Fixirung des Männchens am weiblichen Körper als andauernde Verbindung unterhält. Die beiden unteren Glieder erscheinen aufgetrieben und besonders das zweite stark verbreitet; an Stelle der Endglieder finden wir einen beweglichen mit einer Fiederborste besetzten Haken, der dem beweglichen Arme einer Scheere ähnlich aufwärts gegen der vorausgehenden Abschnitt eingeschlagen werden kann. Am oberen Winkel des letzteren erheben sich noch drei weitere Anhänge, ein oberes Schaufelförmiges verbreitetes und gezahntes Stück und zwei demselben dicht anliegende Zahnstücke welche offenbar in die vorgebildeten Gruben des weiblichen Abdomens eingreifen."

*Second Maxillipede* ♂.—This is a very specialized organ in the adult, subserving as it does the function of prehension—this, in the female, is performed in all probability by the hooked first maxillipede; in both sexes, of course, the second antenna is also modified as a fixing organ.

In the immature male the second maxillipede is merely a blunt cone made up of three segments; the basal portion is swollen and rounded (Pl. 22. fig. 18), with a small spine on the line of union between this and the next joint; this second segment is an undifferentiated ring, which in its turn bears a spine where it connects with the last segment—but this spine is on the opposite

side to the previous one. It is difficult to decide if the terminal papilla-like part is a distinct segment or only a portion of the second; it is, however, quite free of spines or hooks, and it ends bluntly.

There seems to be no stage between this and the adult form, nor can I find any stage earlier than this; apparently there are but these two stages in the male.

The adult organ possesses a very characteristic chelate organization. There is a basal joint which, compared with the next segment, is rather slender, and is directed forwards and outwards (Pl. 22. fig. 18); articulating with this is the main joint, large and strong, on the distal end of which the chelæ work. The chelæ are composed of two parts—a pad (*pd.*) and a hinged beak (*bk.*); the protruding pad on which the beak bites is on the inner surface of the limb; at its base it is surrounded by a circlet of fine setæ; the moveable beak is hinged on in such a way as to close down on this pad, it being worked by powerful muscles. There are no setæ or spines on this appendage in the adult; it is essentially characteristic of the male, there being nothing comparable to it in the female.

The two maxillipedes are so arranged that they slope forwards and inwards, almost meeting in the middle line (Pl. 21. fig. 3, *mp.*<sup>2</sup>), the chelæ thus working *in front* of the mouth-parts. The first and second joints are bent on each other, forming a very pronounced elbow, which points outwards, for the first segment slopes forwards and *outwards*, while the second slopes forwards and *inwards*, the angle between being about 60°.

Close to the basal joint is the first maxillipede, which is considerably flatter in the adult than in the immature stage; in the adult it has the form of a very flat plate of chitin, with its rounded antero-lateral border fringed with setæ.

This appendage in *Goidelia japonica* differs fundamentally from the corresponding organ in *Clausidium*, as described by Claus and Canu. These authors show that in these cases (*Clausidium*, *Hersiliodes*, and *Giardella*) it is armed at the end with a powerful recurved spine in the male (*Giardella*), rather more reduced in *Hersiliodes*, yet in no instance is it a chelate structure as is here shown to be the case. According to Claus, there is a slight resemblance in *Clausidium*, though even there nothing occurs of the nature of chelæ, and the basal joint has a stout seta, while there are numerous defensive weapons at the extremity: "an

Stella der Endglieder finden wir einen beweglichen mit einer Fiederborste besetzten Haken der den beweglicher Arme einer Scheere ähnlich, aufwärts gegen den vorausgehenden Abschnitt eingeschlagen werden kann." However, in this Echiuroid parasite there are no accessory parts to this appendage, only the clear-cut chela closing down to its simple pad. The whole organ forms a powerful prehensile apparatus, and seems to be in no way connected with the function of alimentation. Since Kossmann calls the first maxillipede the "second maxilla," the male maxillipede is, according to his figure, an unjointed upwardly-curved claw, while in the female it is a three-jointed apparatus bearing setæ of various kinds, that of the male being devoid of such processes and a much smaller organ than in the female. In *Goidelia japonica*, as has been shown, this appendage is a mere vestige in the female, and in the male is a powerful chela (Pl. 21. fig. 3, mp.<sup>2</sup>; Pl. 22. fig. 18).

*Thoracic Legs 1-4.*—In the genus "*Hersilia*" Canu says: "Première paire des pattes thoraciques très différentes des trois suivantes semblables entre elles et transformée en organes d'adhésion. Pattes des deuxième, troisième et quatrième somites thoraciques formées de deux articles et de deux rames 3-articulées. Pattes thoraciques de la cinquième paire simples, 2-articulées et aplaties."

In the genus *Giardella*, according to Canu: "Pattes thoraciques des quatre premières paires de forme normale, biramées, à rames 3-articulées; de la cinquième paire simple, 2-articulées et aplaties." Canu looks upon the head with the first thoracic segment as constituting the first metamere; the abdomen thus has five segments, the furca forming a sixth. "C'est la première somite qui porte les orifices génitaux dans les deux sexes. Chez le mâle, ces orifices sont au nombre de deux situés symétriquement sur la face ventrale à la limite postérieure du segment; ils sont recouverts par une paire de pléopodes lamelleux terminés par une longue soie. Chez la femelle, les deux ouvertures génitales sont placées symétriquement dans une situation latéro-dorsale au tiers antérieur du segment."

In the genus *Hersiliodes* the first pair of legs, according to Canu, "sont biramées et triarticulées, sans déformation et parfaitement pourvues de soies natatoires, il en est de même dans les trois paires suivantes, toutefois la rame interne de la quatrième paire est plus allongée et peu riche en soies natatoires."

According to Claus in "*Hersilia*" *apodiformis*: "von den vier zwei ästigen Beinpaaren zeigt das vordere dem Cephalothorax angehörige Paar eine so bedeutende Umformung, dass Philippi diese Gliedmasse als Kaufuss in Anspruch nehmen konnte."

Kossmann says of the same species:—"Die Spaltfüsse des ersten Paares sind zu einem kräftigen Bewegung und Haftapparat umgewandelt welche im Verein mit den übrigen Schwimmfüssen unseren Copepoden ein rasches Umhergleiten auf dem glatten Panzer seines Wirthes möglich macht. Die beiden Grundglieder scheinen mit den zwei ersten Gliedern des inneren Spaltästes zu einer Masse verwachsen zu sein, ohne dass die Contouren der einzelnen Glieder verwischt sind, das eine Grundglieder trägt beim Männchen eine lange Borste, welche beim Weibchen zu einem kolossalen rückwärts gerichteten Dom oder Zahn entwickelt ist. Das andere Grundglied trägt einen kürzeren, etwas nach aussen gekrümmten Zahn, der dicht neben jenem nach aussen zu liegt. Die krümmig dieses Zahnes füllt nun eine Saugscheibe aus, welche ungefähr auf der Mitte des inneren Spaltastes angebracht ist; an der Spitze des letzteren befindet sich noch eine zweite kleinere, nebst drei Zähnchen. Der äussere Spaltast ist schwach entwickelt, viel kürzer als der innere, beim Männchen mit längeren und kürzeren Borsten bedeckt, die beim Weibchen durch Dornen ersetzt sind."

*Goidelia japonica* differs very strikingly from all these various descriptions. The first four pairs of thoracic appendages are very highly specialized, and all alike. Each limb is biramous, and possesses a basal part of two segments, which is attached to a median sternum; this sternum is nothing more than a flat plate of chitin, with a transverse notch in the centre making it appear almost bi-lobed. Posteriorly its free edge is fringed with setæ; laterally (Pl. 22. fig. 19, s) there articulates with it the first and smallest segment of the basal part of the limb (*b*<sup>1</sup>); this segment is small and irregularly shaped, bearing on its inner surface one long feathered seta which runs parallel with the setose edge of the sternal plate (fig. 19). The other basal segment is three or four times as large as this joint and rounded, its anterior (or outer) surface being smooth; on its inner surface (Pl. 22. fig. 19, *b*<sup>2</sup>), near the articulation with the first basal joint, there is a very powerful short spine recurved and feathered, its insertion being apparently sunk in a small pit. The inner ramus of the limb is attached on this surface near the

spine; both rami have three articulations. The inner branch bears long feathered setæ on its inner face, one on each of the first two joints, and six on the terminal joint, three of which arise laterally and three at the extreme tip (Pl. 22. fig. 19). The opposite surface is clothed with soft fine setæ. The outer ramus is also adapted for locomotion, the first joint exhibiting distally on its outer face a short, sharp spine; a corresponding spine occurs on the second joint, which has in addition a long bearded seta on its inner side. The terminal joint has the sharp stout spine on its outer face, but on its inner surface and at the tip there are four long feathered setæ (fig. 19), with a fifth one, much smaller, pointing outwards. The whole outer surface of these three joints is covered with soft fine setæ.

The thoracic appendages of *Goidelia japonica* possess no sucking-discs like those occurring in the previously-described forms.

*Thoracic Leg, 5.*—In both sexes this is a uniramous organ, very feebly developed. It is practically the same in male and female, though in the latter (adult) it is broader and shorter relatively than in the male; in both cases it consists of three short equal segments, the first two each armed laterally with one long seta, the terminal segment carrying two (Pl. 21. figs. 2, 3).

*Abdomen.*—The first abdominal segment of the mature female is conspicuously larger than any of those following it. In reality it is not one segment, but is formed by the fusion of three; on its ventral surface it is pierced by a pair of genital pores (fig. 2, *g*) placed obliquely.

The abdomen in the adult male is marked with a lateral spine, borne on the first segment (fig. 3, *g*); near the base of each of these the minute genital openings are placed. The ventral border of this segment is fringed posteriorly with setæ (fig. 3); this edge is not parallel with the other rings, but slopes forwards to the centre, where there is a clearly-defined square area (*x*)—the significance of this is obscure, but it may have some sexual function to perform.

*Furcæ.*—The furcæ are short and offer no evidence of dimorphism between the sexes; each possesses a long inner seta and a shorter external one. The groove between the furcæ runs far forwards on the dorsal surface, and the anus opens into it on the last undivided abdominal segment. Ventrally the groove is less conspicuous, and does not continue so far forwards as on the dorsal surface.

*GOIDELIA JAPONICA*, nov. gen. et sp.

*Diagnosis of Generic Characters*.—Body flattened, segmented, and cyclopoid; sexes equal in size, dimorphism only being apparent on closer examination of the appendages; the male not attached to the female; no eyes.

*1st antenna* alike in female and male; composed of 5 segments.

*2nd antenna* alike in female and male; composed of 4 segments, forming a characteristic elbow; the three terminal segments constitute a powerful hooking apparatus.

*Mandibles* alike in female and male; very small and claw-like; with no accessory parts (such as occur in the other known genera).

*1st maxillipede* ♀ differs much in the immature stages; in the adult it is a claw-like organ with two recurved hooks (in the other genera this appendage is alike in both sexes, being very highly developed).

*1st maxillipede* ♂ alike in all stages; very degenerate, being only a fringed plate.

*2nd maxillipede* ♀ alike in all stages; very degenerate, being only a papilla (in the other genera this appendage shows sexual dimorphism, but in both sexes it is very highly developed).

*2nd maxillipede* ♂, different in the various stages; very specialized as a powerful chela (in the other genera there is no suggestion of a chelate apparatus).

*Thoracic legs* 1–4 all alike; biramous; no sucking-discs (such as occur in the other genera, where also the 1st leg is unlike the others).

*Thoracic leg* 5 uniramous in female and male.

*Abdomen* of 6 segments; in the female the first three are fused.

*Furcæ* show no difference in male and female; each furca bears a long and a short seta.

*TRICHODINA* (n. sp.). (Pl. 22. fig. 20.)

The rectum of *Echiurus uncinatus* gives shelter not only to the parasitic Copepod *Goidelia japonica*, but also to a minute Infusorian: being so excessively small, this creature would in all probability have escaped my notice had it not occurred in such abundance. I first saw it in a series of transverse sections of the whole *Echiurus*, where it was very conspicuous in all sections of the rectum, for the methylene-blue which I was using as a double stain settled far darker in these little parasites than in any



of the surrounding tissue. On examining the contents of the rectum, I found that it contained immense numbers of these Infusorians, but having only preserved material at my disposal I was unable to investigate more than the most salient features; in fact, to make out these points many different reagents and stains had to be used. On the whole, I found it best to first clear the material of corrosive sublimate by immersion in iodine solution, then stain with alum-carmine, finally clearing in oil of cloves.

As is seen in fig. 20, the form of the body is quite spherical when looked at from above (as in i.) or from below: ii. shows a lateral view. It is not easy to say without watching living specimens, or at least examining fresh material, which is the anterior and which the posterior end. Above and below there is a circlet of cilia; at one end they encircle a depressed pit-like area around which there seemed to be signs of a skeletal ring of spines or hooks (ii., *h*). At the opposite end the cilia surround a dome-like protuberance—which may, however, have been thus forced out as a result of *post-mortem* contraction. In the rim in which the set of cilia are inserted, I saw, in many specimens, indications of a gullet, or oesophagus; this would point to the fact that this is the anterior end, which would go first in swimming. Situated just beneath this crown of cilia there is an enormous darkly-staining nucleus; it is very long and constricted at intervals so as to look like a string of beads (*nc*).

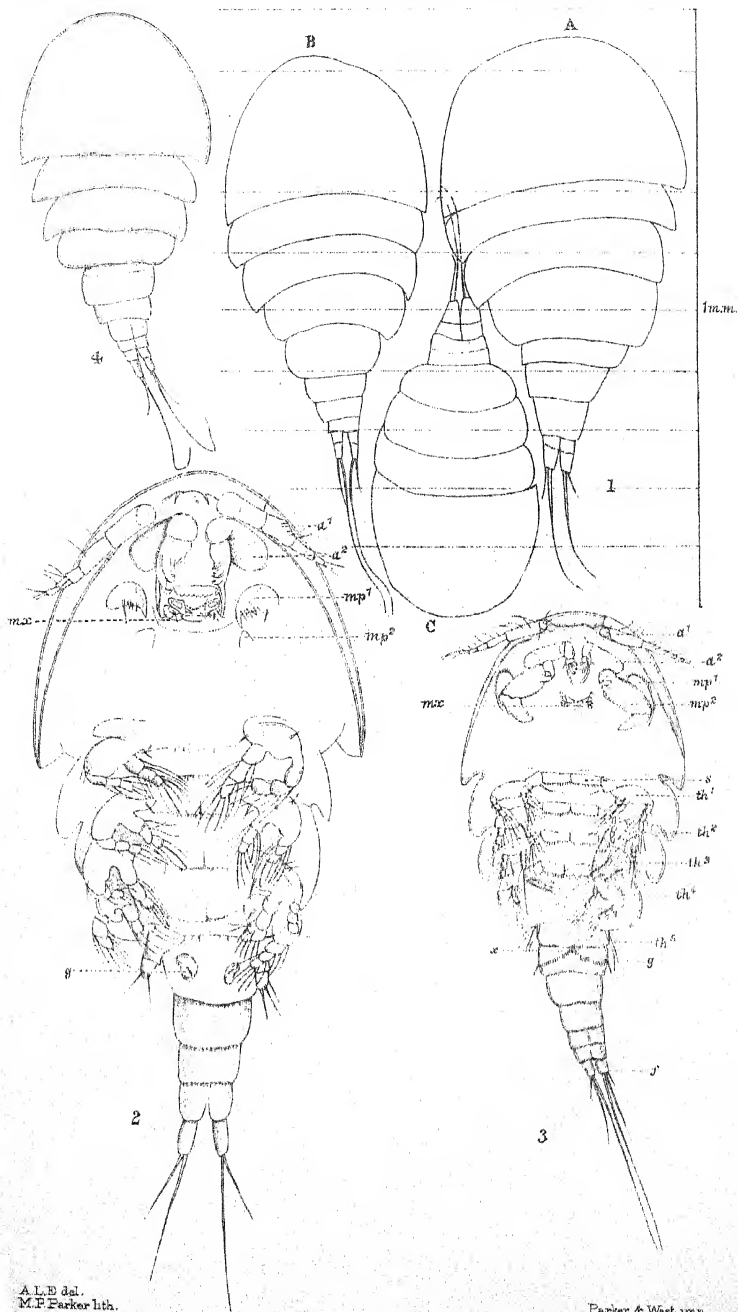
A clear spot was present near the nucleus, which may be the contractile vacuole, or a reservoir (*vc*).

So far as I can form an opinion from the material at my disposal, this is a new species of *Trichodina*, a peritrichous Infusorian related to *Vorticella*. The common species is found creeping about the surface of *Hydræ*; but I find that a representative of the genus has been met with (by Rosseter \*), living an endoparasitic life in the viscera of the newt; very few were found in the testes, but myriads occurred in the renal organs—it is stated that long dearth of water in no way hurts them. This Japanese species may be identical with the form occurring in the newt, for it also leads a truly entozoic life within the rectum of its host; but as this alone is not sufficient to justify the application of a new specific name, I prefer to leave the question of species open, pending a fuller knowledge of the creature and of the habits of the accepted species of the genus.

Cambridge, Nov. 1900.

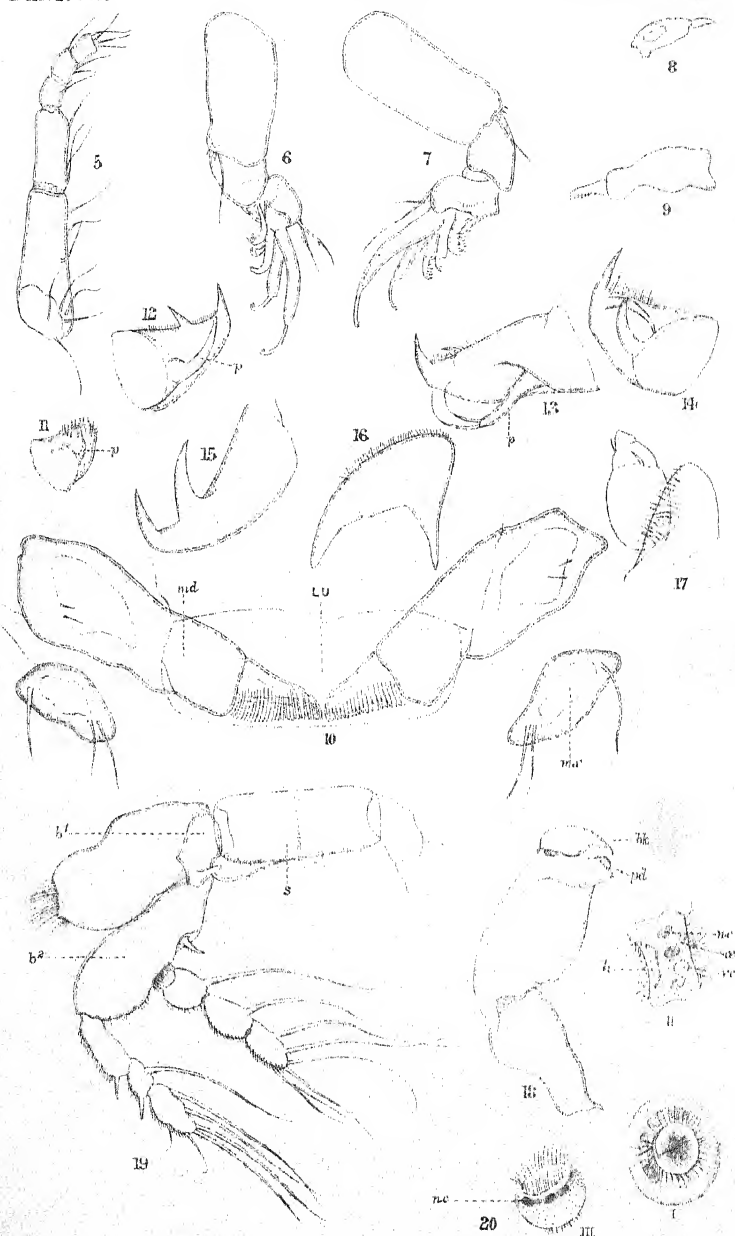
\* Journ. R. Micr. Soc. vi. (2) pp. 929-933, 1 pl.





A NEW ENTOZOIC COPEPOD.





A. E. del.  
M. P. Parker lith.

Parker & Westrup.

A NEW ENTOZOIC COPEPOD.

EXPLANATION OF PLATES 21 & 22.

*Reference Letters.*

A=adult ♀. B=adult ♂. C=immature ♀.  $a^1$ =first antenna.  $a^2$ =second antenna.  $b^1$ =first basal segment.  $b^2$ =second basal segment.  $bk.$ =beak.  $f$ =furca.  $g$ =genital pore.  $h$ =hooks.  $l.l.$ =lower lip.  $l.u.$ =upper lip.  $md.$ =mandible.  $mp.^1$ =first maxillipede.  $mp.^2$ =second maxillipede.  $mx.$ =maxilla.  $nc.$ =nucleus.  $æ$ =æ sophagus.  $pd.$ =pad.  $p$ =palp.  $s$ =sternal plate.  $th.^{1-5}$ =thoracic legs 1-5.  $vc.$ =vacuole.  $x$ =curious glandular patch between 1st and 2nd abdominal segments in the adult male.

*Goidelia japonica.*

[Figs. 1-19 drawn with the *camera lucida*.]

Fig. 1. Outline-drawings of:—

A. Adult ♀. B. Adult ♂. C. Immature ♀.

Superposed on a correspondingly magnified millimetre-scale, the divisions of which are to 1/10 mm.

2. Stage B of 1st maxillipede ♀, drawn from the ventral face, and magnified considerably more than figs. 3 & 4.
3. Adult male from the ventral side, showing the peculiar modification of the two basal abdominal segments.
4. Dorsal view of young female.

[Figs. 5, 6, 7, 8 all drawn on the same scale to show relative sizes.]

5. First antenna.
6. Second antenna, ♀.
7. „ „ ♂.
8. Mandible showing terminal claw.
9. „ on an enlarged scale.
10. Mouth-parts *in situ*, showing the upper and lower lips, mandibles, and maxilla.

Figs. 11, 12, 13, 14, 15.—Stages in the development of the first maxillipede ♀—all drawn on the same scale.

11. Stage A, showing the undifferentiated condition.
12. „ B (ventral view).
13. „ B (dorsal view).
14. „ C, showing the new hooks folded up within.
15. „ D, adult organ.
16. First maxillipede ♂.
17. Second maxillipede ♂, immature stage with chela undifferentiated: the first maxillipede is shown *in situ*.
18. Second maxillipede ♂, adult chelate form.
19. One of the first four thoracic legs, showing its relative position to the sternal plate.

*Trichodina* ? sp.

Fig. 20. *Trichodina*, showing the curious beaded nucleus in various positions, with the two circlets of cilia and the clear vacuole (contractile vacuole?).

On the Structure and Habits of the Polychæta of the Family  
*Ammocharidæ*. By ARNOLD T. WATSON, F.L.S.

[Read 20th December, 1900.]

(PLATES 23-25.)

It is a somewhat curious fact that, although the members of this interesting family of tubicolous Polychæta are widely distributed, and some of them abundant, upon the British shores, they have thus far received comparatively slight notice at the hands of British naturalists. Yet almost sixty years have elapsed since Delle Chiaje first brought these worms to light, and figured a specimen in some detail, to which he assigned the name *Owenia*. During those sixty years, contributions towards a full description have, from time to time, been made by Grube, Kölliker, Claparède, von Drasche, McIntosh, Cunningham and Ramage, Gilson, Lo Bianco, and Ogneff, all of which have been ably summarized by de Saint-Joseph in his 'Annélides Polychètes des Côtes de France.' Nevertheless, as much remains to be learnt of their structure and habits, the following notes may perhaps be regarded in part as supplementary to Prof. Gilson's paper, since it was on his suggestion (27. p. 381) that I have paid special attention to certain of the points hereinafter mentioned. They are the result of observations extending over a period of about three years, some of which were made at the Marine Laboratory at Port Erin, whose Director, Prof. Herdman, has rendered me most valuable assistance; the larger part at Sheffield, on specimens obtained from the coasts of Lancashire and North Wales; and also on foreign specimens, both living and preserved, for which I am indebted to Doctors Dohrn and Lo Bianco, of the Zoological Station at Naples.

I also acknowledge, most gratefully, my indebtedness to my friend, Dr. Fauvel, for valuable advice on points of technique and bibliography. The methods of research described in his admirable work, 'Les Ampharétiens,' have frequently been useful to me.

In the absence of an English description of the Ammocharidæ (a family created by Grube), it will perhaps be well, in the first place, to give a general account of their characteristics, embodying my own observations with those of other naturalists,

and thereby making the later portion of my paper more intelligible.

The body of the animal is cylindrical, and especially rigid in the anterior portion. It consists of from twenty to twenty-seven segments (Pl. 25. fig. 20), and varies in length from about 30 mm. in the English to 90 mm. in the Italian species. The diameter at the anterior end measures from 1 mm. to 3 mm. The cephalic segment is slightly swollen and bears a crown of flat, lacinated, tentacular branchiæ, six in number (*b.t.*, Pl. 23. figs. 1, 2 & 3) (three on either side of the body), which are ciliated on the inner surface. These are absent in the youngest specimens, the mouth being then surrounded only by a funnel-shaped lip, which is quite entire except for a ventral notch. The processes first appear short and squarish in form, with a slight indent on the upper edge, which gives the margin a castellated appearance. In fully-grown living specimens their height somewhat exceeds the diameter of the cephalic segment, but in preserved animals it is slightly less. Each process has a wide, very flat base, giving rise to three or four branches, which are subdivided into seven or more twigs, each terminated by two small rounded mucus-secreting lobes. The crown and branchial processes are well supplied with cœlomic fluid; and in the living specimens the latter have, under favourable illumination, a beautiful appearance, due to the branches from the dorsal blood-vessel and to the network of capillaries with which they are furnished. In British specimens the processes, viewed by transmitted light, are semitransparent, pale greenish blue, or yellow, and tinted with red; whilst those from Naples are blood-red and in parts coloured with a reddish-brown pigment. In cross-section the branchiæ are somewhat horseshoe-shaped, the concave side directed towards the mouth. They are divided into two lateral groups dorsally by a crescent-shaped lobe (*c.l.*, Pl. 23. fig. 2), which is figured and described by von Drasche (12. p. 13) as the head containing the brain. This organ possesses another interesting feature, which seems to have escaped his notice. From his admirable drawings (12. pl. i. fig. 3), it would appear that the inner wall of the lobe is in unbroken continuity with the ectoderm. Favourable sections, however, clearly show that this is not the case, and that for a short distance at the apex of the crescent the inner wall is entirely separated from the outer body-wall and forms a kind of ciliated upper lip, which, by



means of a network of muscular fibres, can be opened or tightly closed at will (*c.p.*, Pl. 24. fig. 8). Free communication can be thus established between the coelomic fluid-containing cavity and the surrounding sea-water. The ventral separation of the branchial processes is, doubtless, a development of what appeared originally as a "notch" in the funnel-shaped lip.

It is interesting to note that one member of this family, *Myriochele* (Mgrn. 4. p. 211, and 13. p. 410) is distinguished by the absence of cephalic branchiæ, development of these organs having apparently been checked at an early stage.

During life the interior of the base of the crown is occupied by three lobes (Pl. 23. fig. 2), namely, the dorsal (*c.l.*), already mentioned, and two lateral ones (*l.l.*) formed by swellings at the base of the ventro-lateral branchial processes, which, distended by the coelomic fluid, and meeting in the centre, may form more or less completely a kind of vestibule—an arrangement which appears to have hitherto escaped notice. Beneath these lobes, which almost disappear owing to contraction in preserved specimens, is the mouth (*m.*, Pl. 23. figs. 1 & 3), a transverse opening situate a little distance from the inner dorsal surfaces, the space between the mouth and the ventral boundary being occupied by the peculiar "Lippen-organ" (*l.o.*, figs. 1, 3 & 7), with its massive bilobed lips, first figured by von Drasche (12. p. 6, pls. i. & ii.), the functions of which will be hereafter described. The branchial crown is marked off from the "thoracic" region by a reddish-brown fold, which commences laterally and becomes very prominent dorsally (*c.*, Pl. 24. figs. 7 & 8).

There is a single black or dark-coloured "eye-spot" on the ventral face of the crown (*e.*, Pl. 25. fig. 20), situate at the base of the branchiæ on either side of the opening.

The segments are neither divided by distinct constrictions, as in *Arenicola* and *Olymene*, nor are they sharply divided from each other; only here and there does the body contour show a slight incurving, indicative of their demarcation (Pl. 25. fig. 20). The "thoracic region" comprises the buccal segment and three other short segments fused together, the only external indications of which are three bundles of simple yellow, slightly pinnate bristles. Of these, the first two only are visible in the ventral view (Pl. 25. fig. 20); as the third bundle, consisting of much shorter and less numerous bristles, is situate quite dorsally. Internally there is a septum between the buccal

segment and those which follow it, but the next three segments are without septa and enclose a single chamber. The succeeding three "abdominal" segments increase in length, the seventh being sometimes four or five times as long as the buccal and "thoracic" segments taken together. From the eighth segment their length is rapidly reduced, the penultimate segment being very minute. The "thoracic" region and each of the "abdominal" segments is internally cut off from its neighbour by a septum; and with the exception of the anal, the penultimate, and antepenultimate segments, the anterior extremity of each is indicated externally by a bundle of dorsal or dorso-lateral setæ. These setæ are slightly pinnate at the extremity. Each bundle of setæ is followed by a torus, which, in the abdominal region, is so long that the tori (*t.*, Pl. 25. fig. 20) on the two sides almost unite at their extremities, and, at this part, form approximately a complete girdle; though in the last segments the tori will not extend over more than about one-sixth of the circumference. The tori of the first four segments are red owing to the presence of blood. From each torus proceed a considerable number of minute bifid uncini (Pl. 23. fig. 4), which are disposed in very regular, close-set, longitudinal rows (*u.*, Pl. 23. fig. 6); and it has been estimated by de Saint-Joseph (29. p. 401) that there will be about 7600 uncini in a single torus in the third "abdominal" segment. The total equipment of an entire animal is estimated at from 150,000 to 450,000 hooks.

This immense provision of uncini is necessitated by the burrowing habits of the animal, and renders it most difficult to expel the living worm, uninjured, from its tube. The anterior part of each uncinus is preceded by an enlargement, which tends to retain it in the epidermis in which its shaft is buried, though this provision is not always sufficient, as uncini may occasionally be found torn from the tori and embedded between the layers of the inner lining of the tube. Sickly worms, too, occasionally expel their uncini from the mouth of the tube. The shaft of the uncinus is flat and straight, and terminated proximally (Pl. 23. fig. 4, *c'*) by a thread-like elongation, which curves sharply backwards and penetrates the basal membrane. The uncini are actuated by appropriate muscles, and are used for seizing-purposes at will. There are no ventral uncini in the "thoracic" segments, neither are there any dorsal setæ

in the penultimate and antepenultimate. The anal segment has no setæ of either kind, and is truncated so that the ventral face, which is terminated by two small lobes (*a.p.*, Pl. 25. fig. 20), extends slightly further than the dorsal. These lobes, as will be seen hereafter, are of special interest. The margin of the anus is ciliated and crenated. In a dorsal, external view of the animal, longitudinal, paired, milk-coloured bands are seen extending as far as the fifth torus (12. p. 10). These are due to a thickening of the epidermis. The first pair take their rise laterally, and, curving towards the back, terminate at points against the bundles of setæ of the first torus. From these points there spring a wider pair of bands, which, in the form of bows with their convex sides facing each other, tie together the setæ of the first torus to those of the second. Similar bows bind together the setæ of the three following segments.

An olive-green zigzag canal runs almost from end to end of each of the bands of the second "abdominal" segment (*e.c.*, Pl. 23. fig. 6). Nephridia have not yet been found in the Ammocharidæ; but it seems probable that these canals, with their internal funnel-shaped mouths and external slit-like openings, represent those organs, though Gilson is mistaken in supposing that they play a part in the emission of the genital products (27. p. 379). These, as I shall show, are discharged through characteristic pores at the anal extremity.

A lateral view of the "thoracic" segment shows an interesting point of adaptation of the animal to its mode of life. Von Drasche (12. p. 9) has noted the fact that, although the markings are not quite constant, there is, in the dorsal part of the collar, a transverse patch of brown colour, often divided into two portions by the dorsal line. This coloration extends as a line on either side round the fore-edge of the thorax, and swells into the round pigment-spots (eye-spots?) already mentioned. From these spots the lines descend, and, still going forward, meet at an acute angle on the ventral line, about the level of the first bundle of bristles. He also observes that, in the anterior part of the animal, the course of the nervous system is practically indicated by this coloration; the dorsal patch marking the brain, whilst the lateral lines indicate the œsophageal commissures uniting in the large ganglion, from which springs the ventral cord. This consists of a dotted band, without ganglia or large nerve-fibres, which runs the whole length of the animal.

The entire nervous system is fully described by von Drasche (12. p. 13), who observes that it is very rudimentary in character, and lies outside the muscular layer near the surface of the epidermis.

It may be asked whether the localization of the coloration over the nervous system may not be connected with the animal's sensitiveness to light? Some of my sections seem to suggest the possibility, but at present this must remain undetermined. I am able to show that a special function is performed by the triangular ventral area (*v.a.*, Pl. 25. fig. 20) bounded by the two lines which descend from the "eye-spot." The body-wall is at this point very much thinner than that of adjoining parts, and modified, as I shall show more fully, in relation to the building-habits of the animal.

The structure of the creature is remarkable in many other respects, and for minute anatomical descriptions reference should be made to the papers of Claparède, von Drasche, Gilson, and Ogneff. Speaking generally, I may point out that a cuticular covering to the epidermis is absent, except on the anterior portion of the body; that the underlying circular muscles are limited to the "thoracic" region; and that the longitudinal muscles, which are exceptionally powerful, form throughout its entire length an inner lining for the body-cavity—a layer which is continuous except where it is interrupted by the dorsal and ventral mesenteries of the alimentary canal. These powerful muscles impart considerable rigidity to the fore part of the body; a feature which gradually disappears posteriorly, the thickness of the muscular layer in that part being greatly reduced. According to Gilson (30. p. 95) there are no peritoneal parietes distinct from the longitudinal muscular layer, his view being that these two layers are replaced by one musculo-glandular layer which, amongst other things, is excretory in function. This view is, however, opposed by the observations of von Drasche (12. p. 20) and Ogneff (32.).

A striking and characteristic feature of the Ammocharidæ, which has from the first attracted the attention of naturalists, is the existence in the anterior segments of peculiar, very long, cylindrical, rigid glands (*t.g.*, Pl. 23. fig. 6) of considerable calibre which hang loosely in the body-cavity. Each is attached to the body-wall by one extremity which, greatly reduced in diameter, forms a minute duct running through the body-wall, opening

between the end of the torus and bundle of setæ of that side of the segment to which the gland belongs. There are sometimes seven pairs of these glands, one pair to each of the first seven segments, but those of the third segment may be either rudimentary or non-existent. These are the thread-glands ("glandes filières") of Claparède (6), the structure of which has been fully worked out by Gilson (20). Their function is to secrete—by exudation from the epithelial cells of the wall of the gland (20. p. 317, & 29. p. 402)—a very thick viscous liquid containing bundles of exceedingly fine colourless threads, which are used by the animal in the formation of the membranous lining of its tube, but not, as some writers have suggested, for the attachment of its external stony covering. The secretion for this latter purpose is supplied by the "Lippen-organ" (*l.o.*, figs. 1, 3, 7 & 9). The œsophagus, which is almost as long as the "thoracic" segment, descends directly from the mouth, and is followed by the intestine, which, with a series of swellings and constrictions, runs straight to the anus.

De Saint-Joseph notes (29. p. 403) that in the third and fourth "abdominal" segments the intestine is green owing to the glands which cover it. The alimentary canal passes through the segmental septa, and in addition thereto is supported throughout by a dorsal and ventral mesentery. For the greater part of its length it is surrounded by the dorsal vessel, which forms a peri-intestinal sinus. This sinus bifurcates and leaves the œsophagus on entering the thoracic region. Each branch then goes forward, and, after skirting the nearest group of branchial processes, descends, and, reuniting with its fellow, gives rise to the ventral vessel. Numerous short cæca arise from each side of this vessel, forming round ampullæ, of which de Saint-Joseph states (29. p. 403) that he has counted as many as forty in the third abdominal segment. The blood is red. The septa, which are membranous and traversed by fine muscular fibres, have been specially studied by Gilson (27). They may completely separate each segment from its neighbour, but by means of valves in the intersegmental membranes intercommunication may be established.

These valves (Pl. 23. fig. 5) are of two kinds, namely, a simple slit, making a "flap" valve (*f.v.*), opening like a door towards the anterior, which is always situate dorsally; and a sphincter valve (*s.v.*), which is placed ventrally. I have been fortunate

enough to see both kinds in action, and note that the cœlomic fluid (in which sometimes ova were floating) almost invariably passed steadily through the sphincter valves when travelling towards the anus, and rapidly past the large slit or "flap" valve when going in the opposite direction. In the absence of assistance from circular muscles, it will be seen that the latter form of valve is specially well adapted for rapid release of the imprisoned cœlomic fluid, and that the animal is enabled speedily to retract the posterior portion of its body, in case of danger, by means of its longitudinal muscles. My observations show that, with the exception of the buccal and "thoracic" segments, and possibly the smaller ones towards the anal extremity, each side of each segment is provided with two valves, one of each kind. Those attached to the septum at the base of the "thoracic" segment are described by Gilson (27. p. 384), and are exceptionally powerful. As will be seen later, this is apparently another adaptation connected with the habits of the animal.

The foregoing will probably suffice as a general description of the structure of the worms, and we may next consider their habits. They are exceptionally hardy animals, whose welfare is apparently more dependent upon a good supply of rather muddy sand than upon a liberal allowance of oxygen, since they thrive under conditions so various as those which prevail respectively on the British shores at low-water mark, and at a depth of 2975 fathoms near the Caribbean Islands (13. p. 410); whilst both Dr. Fauvel and I have found them to live for years in small aquaria destitute of alga and without change of either sea-water or sand, the only attention they received being an occasional raking of the surface and the addition of river-water to compensate for evaporation. They are gregarious, and dwell embedded near the surface of the sand in flexible sand-covered tubes. The tube is unique in structure, and, when fully extended, frequently two or three times as long as its inmate. It is well described by Grube (2), in 1846, as a transparent gelatinous tube, the middle part of which is supported with great firmness by a crust of grains of sand and fragments of shell which, when flat, are "glued" on by their highest edges so as to overlies one another like the tiles on a roof.

Gilson (20. p. 322) has given a most careful description of the minute structure of the tube, and although I am unable entirely to confirm his speculations on the mode of its formation, it is

satisfactory to find that his observations on the appearance of the finished tube are quite in accordance with my own, and consistent with what we might expect as the result of the process of building, which I have had the good fortune to witness on several occasions, and shall hereafter describe. From the fact that the sand in the Bay of Naples is singularly devoid of minute flat particles of stone or shell, his specimens would probably not show that most interesting characteristic, "imbrication," mentioned by Grube (2). Gilson consequently does not refer to it; but I know from experience that when suitable material is supplied, these worms gladly employ it in the manner described, and the process by which the desired result is attained is wonderfully ingenious. De Saint-Joseph remarks (29. p. 398) that the fragments of shell are sometimes fixed at a right angle by the edge; but the difference between his description and that of Grube is due to a difference in the state of contraction of the tube at the time of observation. I have frequently seen a tube present both appearances, separated by an interval of, say, half an hour. The tube (Pl. 24. fig. 12) consists of two distinct parts: (1) an external covering of foreign matter (*s.c.*) which may be very minute fragments of shells of molluscs, calcareous tubes of annelids, grains of quartz, or flat particles of other rocks; and (2) an internal tube (*c.t.*) which is translucent, colourless, flexible, elastic, and exceedingly tough—this part being secreted by the worm. The tube as a whole differs, I believe, from all others in that the particles of foreign matter, instead of being more or less attached to one another, are designedly kept entirely apart, firmly affixed only to the inner membranous tube, with the attachment limited to one side or edge (Pl. 24. fig. 12). The structure thus produced is thoroughly protective, and, at the same time, like a coat of mail, it accommodates itself easily to the violent contortions of the body, which are involved in the habits of the worm. Carrying its tube with it, the animal is capable of burrowing through the sandy sea-bottom, and consequently the position of the tube in relation to the surface is by no means constant, though it is usually more or less vertical.

It is interesting to note that the tube itself has an anterior and a posterior end, and is always buried in a definite direction. The anterior, being the growing end (at all events as regards the stony covering), is invariably nearer the surface; whilst the

posterior, which never receives additions except to its internal sheath, may be embedded deep in the sand. The membranous tube terminates at each end with a conical, very elastic tip (*c.f.*, Pl. 24. figs. 12 & 13), which projects more or less beyond the stony covering, and has at its extremity a very minute perforation. At the posterior or buried end, this tip is often preceded by a length of from 10 to 15 mm. of naked tube (Pl. 24. fig. 13), which Gilson (20. p. 322) has mistaken for a secretion at the outset of the animal's existence. It is simply an extension (possibly late in origin) underground, where the worm is unable to affix its stony covering. The animal is capable of reversing in its tube, and thus exploring the sand at either end, and, like the Terebellidæ (17), the Ammocharidæ invariably adopt the sanitary method of ejecting the excreta, at the anterior end of the tube, into the open sea.

When the anterior end of the tube of an English specimen is seen under a low power (Pl. 24. fig. 12), the imbricated arrangement and transparent conical extremity of the internal sheath are very noticeable, the free edge of the bits of stone being directed upwards, whilst the tip, in which is the minute perforation, is drawn in, as is common when the animal is just about to emerge. Gilson (20. figs. 21, 22 & 23) gives excellent figures illustrating the structure of the tube. His longitudinal section of the posterior naked end shows that this membranous sheath consists of a number of layers, and that the lengthening of it is produced by internal additions, which advance by stages beyond the extremity of the external ones, each advance being marked externally by a stepped appearance. This section also shows that the tube is occasionally strengthened by new external additions on the face of the layers previously formed.

Both these points are clearly visible in the drawing of this portion of the tube of *Owenia* (Pl. 24. fig. 13). A cross section shows the internal layers to be concentric. By removing the stony covering from the body of the tube, Gilson demonstrated that the inner sheath is imperforate, and constructed as described from end to end. By means of tangential sections he found (20. p. 323), in the wall of the inner tube, a somewhat irregular system of coarse striæ which, under a high power, he was able to resolve into a large number of very fine, irregular, longitudinal striæ, and to recognize as the filaments



produced by the thread-glands. Gilson's figure, 23, is specially interesting as delineating a section through the complete tube not stripped of its earthy covering. The section was made by a method specially devised by him for the purpose, and shows both the inner sheath of concentric layers and the outer irregular zone. The former is the part first laid down, as shown in the sections of the tip; whilst the latter is formed of masses of foreign materials subsequently affixed to the former by secretion, in which the various fragments are seen to be more or less completely embedded. My own examination of the structure of the inner tube was made by the ruder method of scraping off the sandy covering, and, after subjecting the inner sheath to maceration in distilled water, tearing the layers asunder. In this way I found it easy to separate the external rugged layer (which represents the cement by which the stony covering is attached) from the tube proper, and, by means of stains, to establish the fact that the fibres in the former (which are embedded in a homogeneous secretion) may assume either a radial or any other direction; whilst those of the sheath take a course which is usually more or less longitudinal or transverse in relation to the tube.

This somewhat lengthy preliminary description will render intelligible the questions to which I have successfully directed my attention. They are as follows:—

(1) The method of construction of the imbricated tube and the elastic conical tips.

(2) The reason for the adoption of this particular arrangement.

(3) The function of the "Lippen-organ" or "Metastomium" (Gilson).

(4) The *raison d'être* of the immense number of uncini and of the double form of septal valves.

(5) The existence of a cephalic opening, and of anal pores.

(6) The method of reproduction.

(7) The larval form (*Mitraria*).

I do not now propose to deal with these questions seriatim, but rather with such points as have not already been dealt with, in my account of the habits of the worm. As already explained, the tube has a definite anterior and posterior extremity, and is usually embedded more or less vertically in the sand, the anterior end being always nearest the surface, and also that to which

external stony additions are made. During the day the tube, into which the inmate retreats, is frequently entirely buried; for the Ammocharidæ, like many other annelids, appear to be largely nocturnal in their habits. It is not usually until towards evening that the animal becomes active, and, after exposing ten or more millimetres of its tube above the surface, ventures to protrude its branchiæ.

In order to appreciate the builder's difficulties we must realize the fact that the tube of an annelid is necessarily constructed *from within*; that while it is, so to say, secreted, or built by the worm round its own body, it is so arranged that the inmate shall all the time be entirely detached from it, and free to change its position within it at will. If we imagine the head of the worm protruding through the growing conical tip (*c.t.*, Pl. 24. fig. 12), it will then be seen that, in order to produce the imbricated tube, the base of each new fragment added must be placed carefully underneath the fragments which are already attached, and must be there affixed to the membranous tube; in other words, it must be inserted and fixed between the inner sheath and the last row of fragments added to the outer covering.

Were the process reversed and additions made at the other end of the tube, as by a tiler covering a roof, there would seem to be but little difficulty. The matter would be almost as simple as the placing of one stone above another; but the problem is as I have stated, and its solution (which absorbed considerable time) took me completely by surprise. The beautifully transparent, conical, elastic part of the tube (*c.t.*, Pl. 24. fig. 12), which on retreat of the animal is drawn inwards (the worm thereby frequently pulling together the latest shelly additions and closing the tube with them), is figured as almost fully distended by the water, which is being driven before it by the advancing worm. At first the animal is hidden by the stony sheath, but in another moment the branchial tentacles, contracted and twisted together in the form of a living cone, appear beyond it and fill the elastic transparent tip, which I might perhaps compare to an india-rubber teat. Then, cautiously thrusting the tip of a single tentacle through the terminal pore, the animal carefully feels round to make sure that all is safe. Satisfied on this point, a second tentacle follows the first, then several more; finally the whole branchial crown is forced through the minute opening, and the tentacles, spreading themselves out,

cause the elastic sheath, stretched around them like a sphincter, to slip from their outer surface, and settle as a folded ring about the front edge of the "thorax." For a short distance the "thorax" is also visible through, and tightly invested by, the basal part of the membranous cone. The branchial crown (*b.t.*, Pl. 23. figs. 1 & 2) now appears like a lovely red or golden flower, and, basking in the light, may for a time continue quietly to enjoy the water, which it sets in motion with its tentacular cilia. The expanded tentacles are dorsally widely separated by the cephalic crescent (*c.l.*) into two lateral groups, and just below the outer margin of the crescent a groove, bordered with cilia, is visible.

The ventral division is less apparent, but is marked by the outermost tentacles of each group being, like sentinels, usually slightly advanced within the crown; and whilst the swollen tricuspid lobes (*c.l.* & *l.l.*), with ciliated surfaces, occupy its base (Pl. 23. fig. 2), the dorsal lobe gently rises and falls as though in the act of breathing. But if the call of hunger claims attention, or a desire for work arises, all is changed. The tentacles become lively, the boughs bend towards each other across the open crown, or perhaps throw themselves violently outwards; opposite twigs incline and meet, whilst the bilobed tips, like miniature fingers, twitch and move as though striving to grasp something. Then, as the water does not supply the need, the worm, in its tube, curves over on one side until the surface of the sand is reached, and that which is desired can be obtained. When the animal is thus seeking sand, or fine particles of shell, these at once adhere slightly to the mucus of the bilobed tips of the tentacles, or are grasped by them and worked into the horseshoe-shaped internal hollow, which, as a ciliated channel, conveys them to the base of the crown. When the sandy particle has in its progress reached the three lobes, one of two things happens: it may either be kept in motion for a short time by the surface-cilia, and then be rejected without apparently having fulfilled any purpose whatever (the two ventral tentacles usually acting as "ejectors"), or, conveyed within the grasp of the lobes, it may be carried down, by a kind of peristaltic action, through the opening into the vestibule beneath. Powerful transmitted light is required to observe what follows, and in this way, with the aid of a suitable arrangement of the microscope and a low power, the fragment can be seen to be now revolving with a jerky

motion. It is being manipulated by the "Lippen-organ" (*l.o.*, Pl. 23. figs. 1 & 3, Pl. 24. fig. 7) which, protracted and retracted at each movement, is apparently licking or rasping it, as would the radula of a mollusk. After a few minutes' treatment, the fragment may be ejected by the "Lippen-organ," which, protruding between the lobes, thrusts it upwards, within reach of the ejecting tentacles, which complete the expulsion from the crown. One cannot doubt that, although these worms also swallow fine grains of sand, the process just described is an act of feeding. We may assume that the material last secured, although bearing food upon its surface, was unsuitable for building purposes; but when, by chance, a tempting flat grain of sand, or preferably a minute fragment of shell, is obtained, the "Lippen-organ" assumes a different rôle, namely that of a builder; a function the probability of which was suggested by Gilson (27. p. 381).\* The selected fragment is then passed down into the vestibule as before, and there subjected to the treatment just described, but for a much longer period. By this process any available nourishment is doubtless at once removed from the surface, and the material is most carefully cleaned. Then, all being ready, the "Lippen-organ" (*l.o.*, Pl. 23. fig. 1), having turned the fragment into such a position that the thin edge is uppermost, begins to rise steadily, carrying the fragment in front of it. The two lateral branchial lobes separate themselves widely apart to allow of the passage, and the margin of the crown, between the ventral branchiæ, becomes simultaneously stretched.

The upper surface of the "Lippen-organ," with its two bilobed ends, is now visible, carrying the shell, which it intends to fix to the outer side of the tube. In another moment, the position of the fragment is so changed that the flat side, instead of the edge, shall rest upon the "Lippen-organ"; and this continues to rise, until its bilobed extremity is made to project between the lateral ventral tentacles, and to touch the exterior base of the elastic conical tip, which, by retraction of the cephalic segment,

\* In this connection it is curious to note that, at times, the worm appears greatly to prefer building with white materials, and even specimens from Naples (where, to judge by their tubes, only black materials are available) have been noticed to select white when they had the opportunity, and to reject darker ones supplied to them. What means of colour perception such an organism can possess is an interesting question.

combined with a wonderful special arrangement, next to be described, has been brought within reach. I have called attention to the fact (*antea*, p. 235) that a small portion of the body-wall, represented by a ventral triangular area (*v.a.*, Pl. 25. fig. 20) just above the œsophageal ganglion, is very considerably reduced in thickness. The object of this is now apparent. Simultaneously with the protrusion of the "Lippen-organ," the circular muscles (*c.m.*, Pl. 23. fig. 1) of the lower part of the "thoracic" segment contract, the powerful septal valves (*t.v.*, Pl. 23. fig. 1) are doubtless brought into action, and by means of the imprisoned coelomic fluid a very marked swelling of the anterior part of that segment occurs, especially in the area above referred to, with the result that, at the very edge of the "thorax," a projecting pouch (*t.p.*, Pl. 23. fig. 1) is produced. It will be borne in mind that the tube (*m.t.*) tightly invests the "thorax," as with a skin, and as it consequently covers the pouch, it assumes its form; and from this it may be realized that the lobes of the "Lippen-organ" (*l.o.*, Pl. 23. fig. 1), on being protruded, find themselves pretty nearly on a level with the curved upper covering of the pouch. By a muscular action of the upper surface of the "Lippen-organ," assisted by occasional little pushes from behind, the fragment (*f.s.*, Pl. 23. fig. 1) now commences to travel, sliding along smoothly towards the outer lobes of this, whilst the epidermis on the underside of this end of it is forced upwards and made to take an active part in transferring and affixing the fragment, at a tangent (Pl. 23. fig. 1), to the curved upper covering of the pouch. This done, the "Lippen-organ" is retracted into the vestibule, the "thoracic" muscles are relaxed, the pouch disappears, and the parts resume their ordinary aspect: but the fragment just added will be found standing vertically, with its base in the required position, and the lower end of its inner side firmly attached to the elastic conical sheath. It is certain that the cement for this purpose is supplied by the "Lippen-organ," which must consequently be regarded as a glandular structure.

From my observations of the habits of the animal, I have no doubt that the external thickening of the membranous sheath is also due to the secretion of this organ, and not, as has been supposed, of the thread-glands. The "Lippen-organ," which is seen *in situ* in the longitudinal section of the "thorax" (*l.o.*, Pl. 24. fig. 7), is beautifully figured by its discoverer, von

Drasche (12. pl. ii. fig. 3), who describes it (12. p. 6) as being composed of two dorso-ventral lips (facing each other), of which each is bilobed, "in a form similar to that of *Ascaris*"; the dorsal lip being generally rather the larger. In preserved specimens, the two lips are usually found separated from each other by about  $180^{\circ}$ ; but in life they are inclined towards each other at various angles.

Where the bases of the two lips touch there is a small deep fold, which, however, is cæcal and does not lead into the body-cavity. The organ is retracted by means of a local folding of the centre of its cup-shaped membrane.

You Drasche adds (12. p. 12) that the organ is a folded portion of the epidermis, consisting of high, wedged-shaped, badly staining, ciliated cells, with small nuclei. As regards preserved specimens, I shall not attempt to improve upon this excellent description, except to question the existence of the ciliated nature of the cells, at all events as regards the upper surface of the organ. I have seen it at work many times, and although I have observed ciliary action on the dorsal lobe and other parts, I have failed to detect anything of the kind on its surface. On the contrary, the impression, conveyed by watching the living animal, is that the function of these tall, transparent cells is the secretion of the cement for attaching the outer stony covering and strengthening the membranous tube. In certain operations, which I hereafter describe, the ventral end of the organ is protruded between the ventral tentacles, so as to bend far over the edge and manipulate the outside of the membranous tube. On such occasions the organ presents a beautiful semitransparent appearance, with the two protruding terminal lobes, tensely distended as from pressure of the secretion with which they are charged. A transverse section (Pl. 24. fig. 9) of this end of the "Lippen-organ" shows that the clear, tall cells, which are so noticeable on the upper face, have disappeared from the under, and given place to much shorter nucleated cells and a folded arrangement of the epidermis (*l.c.*). From the way in which the latter structure is protruded, and takes part in the operations of the animal, I have no doubt that some of the secretion is discharged from its surface, probably near the centre line, below the ventral end of the organ, although a discharge may also take place from the upper surface, as is clearly shown in the central fold of one of my sections.

The contents of the first two pairs of thread-glands, like those of the long cells (*h.c.*, Pl. 24. fig. 9) of the "Lippen-organ," strongly resist stains, and it seems very probable that their secretions are identical. The fact that the secretion of the "abdominal" thread-glands stains more readily, may possibly indicate some difference in composition.

The membranous conical tip (*c.f.*, Pl. 24. fig. 12) is a characteristic and essential feature of the tube, and in the event of its accidental removal it is at once re-formed by the worm. By taking advantage of this fact, I have been enabled to make two very interesting observations on (1) the method by which the membranous tube is formed, and (2) the means by which the animal can easily, at will, cut off any desired portion. The latter is a habit which I had noticed to exist, from frequently finding fragments in the aquarium cut off evenly as though with a knife; showing that the worm possesses some special means of accomplishing the apparently difficult task of cutting through the tough membranous sheath. In order to make sure of these observations, a healthy vigorous worm was selected, carefully removed from the aquarium, and placed in sea-water in a glass dish. The tube, as usual, was considerably longer than the animal, and to induce work I at once cut off enough from each end to reduce the tube to about the length of the tenant, taking care, of course, not to injure the worm. This, in its shortened tube, was then transferred to a shallow glass dish containing fresh sea-water, and watched under the microscope. Very soon the animal became aware of the unusual "draughtiness" of its dwelling, and proceeded to investigate the position by cautiously protruding its tentacles and examining the edge of the tube. Having ascertained the extent of the damage, and by repeated search satisfied itself that no enemies were near, it retired just within the shelter of the tube, so that the tips only of the branchial tentacles were, now and then, visible at the fractured end. By transmitted light, it was just possible to see between the sand-grains, and through the membranous tube, that something was going on inside: the branchial tentacles were more or less completely twisted together; the worm was revolving slowly within its tube, with the first bundle of setæ in motion, and it occasionally advanced slightly and then retreated. This process continued for varying periods (apparently dependent upon the intensity of the light), which sometimes extended over

an hour or more; and then a swelling of the tube suddenly commenced, at a point about a millimetre distant from the fractured end. This internal swelling gradually separated the sand-grains far apart, and, through the interstices, it could be seen that the branchial tentacles were tightly screwed together to form a solid living cone, and that the fore part of the "thoracic" segment was so fully distended by the coelomic fluid, that all trace of a division between it and the base of the branchial crown had disappeared. The worm kept up a constant revolving motion, the bristle-bundles being actively at work, whilst, between the ventral tentacles, both ends of the "Lippen-organ" (*l.o.*, Pl. 23. figs. 1, 3, & 7) simultaneously rasped the membranous tube, their ventral lobes striking downwards, and their dorsal lobe vigorously pulling in the opposite direction. In a few minutes the tube was in this way burst and cut through, the severed part or ring being gradually thrown off by the tentacles, which, quietly unfolding themselves one by one, withdrew from the interior and passed the ring over their tips. Freed from the stony encumbrance, the branchial tentacles were seen to be naked and fully exposed to the water; but careful illumination showed that the "thoracic" segment was once more invested with a new membranous, tightly-fitting covering, so beautifully transparent as to be almost invisible, and this I found to be the foundation layer for the new conical tip. It had been formed while the animal was sheltering and revolving in the old tube; the necessary secretion being doubtless supplied by the first two pairs of thread-glands, and passed forward, by and over the tentacles, which, as I have stated, were screwed together so as to form a conical mould. On one occasion, a tentacle was seen to be extended beyond the rest, as though to form a pivot to keep the minute aperture at the tip of the tube open. Immediately the tentacles were freed from the stony ring, the animal proceeded to complete the formation of the membranous tip. It advanced so far in its tube that the whole of the branchial crown was exposed, and the new tip, as a transparent skin, was fully stretched over the "thoracic" segment. Then, for the space of five minutes, the first two bundles of bristles worked vigorously, like brushes, spreading the cement which, with accompanying violent contortions of the body-wall, was poured out by the thread-glands, the animal meanwhile keeping up a constant, steady revolution within its tube. Then



the edge of the new tip (and sometimes the interior) was manipulated by the underside of the ventral end of the "Lippen-organ," and the animal once more retired into the stony tube. It was found that a beautifully perfect, though apparently delicate tip had been produced. After a short interval the other end of the tube was similarly renewed.

The part taken by the setæ in this operation is, I think, noteworthy. It has hitherto been overlooked, and as I have witnessed it in the tube-forming operations of *Panthalis* (24) and *Nerine*, it is probably true of other annelids. Although it was impossible, owing to the stony covering of the tube, to see what was taking place low down, there can be no doubt that the action, as regards the "abdominal" thread-glands, would be a repetition of what I have described. Gilson's interesting experiment shows that a marked exhaustion of the contents of the thread-glands results from the repairing and extending of a fractured tube. As already stated, the lengthening of the tube is due to constant additions, internally, of new membranous tips, the old layer always being forced outwards; consequently, the description of the formation of the membranous tip is really a description of the formation of the outer layer of the completed tube. As I have shown, it is due to the secretion of the thread-glands of the "thoracic" segment, supplemented by those of the "Lippen-organ." Its outer coating, during the life of the animal, is quite unaffected by the sea-water, and it is obviously impossible for it to be renewed. It is an interesting fact, however, that the tube as a whole, though exceedingly tough during the life of the animal, speedily decomposes after its death or expulsion; and it would seem probable that during life a constant renewal of the internal layers is taking place, and that these (which are doubtless due to the secretions of the larger glands) differ, in composition, from those of the outer sheath—a probability which is also indicated by the difference in the reaction to stains already alluded to.

The tube is essential to the existence of the animal, which, when in great straits, bending its body into the form of the letter S, will make a tube only one third of its own length suffice temporarily for its protection; but if, by chance, the worm should be expelled from the tube, death will follow after a short time, as the animal is then, like the *Serpulidæ* and some other worms (19. p. 75), evidently quite incapable of replacing it.

The Ammocharidæ are generally regarded as "sedentary worms," but, from what has been said in the earlier part of this paper, it will have been gathered that their habits are not entirely of that character. Members of this family are, in fact, capable of burrowing in their tubes through the sand; and although this is usually done without travelling far afield, still they are quite capable of working their way through a considerable thickness to the surface, or of leaving the sand entirely, and reburying themselves in new sites. Experiments made with the object of learning something of these habits, have elicited interesting facts. When the worm is first captured and exposed, say by digging and rapidly washing away the sand by means of a sieve, it is generally found that the tube is of considerable length, firm and swollen at the part where the worm at the time happens to be, but diminishing to the diameter of thin twine in the unoccupied portion. In English specimens, the large proportion of fragments of shell in the outer sheath imparts a striking whiteness to the tube. A ball of sand, loosely held together by mucus, is commonly found covering the short length of otherwise naked tube at the posterior extremity. This is, doubtless, formed by the branchial tentacles. From the nature of the building-operations, it is obviously impossible for the "Lippen-organ" to properly affix sand-grains underground, though there is ample evidence, in the form of imprints (*d*, Pl. 24. fig. 13), that this organ strengthens the membranous tube by external additions of its secretion. If such a tube be left in sea-water, without sand, it will be found, after an interval of an hour or two, that it has entirely changed its appearance, and has become spindle-shaped, and only one half or even one-third of its original length. The worm, having drawn over itself the portion which was previously unoccupied, has thus caused the fragments of shell or sand to come more closely together and stand at right-angles to the length of the tube. If the specimen be now reburied beneath a few inches of sand, it will be found, after a short interval (varying of course with the thickness of the layer), that it has burrowed upwards, so as to bring the anterior end of its tube to the surface, a position which is apparently needful for its welfare; and when it is remembered that, in doing this, the free edges of the external fragments have been so placed as to meet with the greatest resistance from the surrounding sand, it will be realized that the operation involves great

muscular exertion. The necessity for the unusually ample equipment of uncini in the "abdominal" region, in order to carry the tube with the body, is thus explained.

The rate of burrowing is not, of course, rapid when a considerable thickness of sand has to be penetrated, ten hours being required, under favourable circumstances, to bore through 150 mm., though 20 mm. would be run through in a few minutes. As the tube is very similar in colour to the sand in which the animal dwells, observation upon its displacements was at first impossible; but, by the admixture of a sufficiently large proportion of white (Calais) sand, I ultimately ascertained the burrowing act to consist of a combination of an undulatory with a screwing motion. When engaged in this operation, the animal occupies the anterior end of the tube, the conical tip of which is filled by the densely-packed tentacles; while the first row of shelly fragments, spread out, possibly forms a cutting edge. By twisting the anterior portion of the body and tube round in the sand, the animal practically converts them into a short hollow screw, about 10 to 15 mm. in diameter, which, working somewhat spasmodically at intervals of a minute or two, to afford time for rest and stretching the tube, gradually makes its way to the surface. On reaching this, the action of the worm confirms the observation in a very curious manner, as, in order to get the desired length of tube exposed, it bends hard over, and pressing on the surface of the sand, describes another revolution with its anterior end, which results in a further stretching of the tube, accompanied by the formation of a saucer-like hollow in the sand. It will be noticed that I speak of stretching the tube; and in explanation I may state that, as a rule, the animal does not carry the whole tube bodily with it to the surface, but attains its end by causing it to stretch the required distance. In some of my experiments, a tube apparently only 65 mm. long stretched to a length of 200 mm., but when again uncovered contracted to its original dimensions. Occasionally, however, the animal, for the purpose of changing its habitat, quits the sand, and in this case it brings the whole tube with it. This is an act which probably sometimes costs the animal its life, for McIntosh states (10. p. 103) that *Owenia filiformis*, with its gravelly tube, is a favourite food of haddocks, cod, and flounders. In order to re-bury itself, the worm reverses its position, and, protruding the branchial tentacles through the opening at the posterior end of the tube,

proceeds to force them into the sand. In this operation it is assisted by the "Lippen-organ," the ventral end of which, acting very much like the foot of a mollusk, strikes over the edge of the membranous tube, and so, with its underside, digs a burrow in the sand, enabling the animal gradually to screw itself downwards. The "thoracic" setæ also appear to take part in this work. This operation is much slower and more laborious than the upward burrowing, and the animal not unfrequently cuts off, and leaves on the surface, a portion of the tube. The tube is thus re-embedded in its natural position; and it is very unusual indeed to find a tube in which a change in the direction of building has taken place, though I am bound to admit this occasionally occurs.

With reference to the method of reproduction, Claparède (6), von Drasche (12. p. 20), and Gilson (30. p. 99) have respectively described the formation of the sexual elements as taking place on the walls of the ventral blood-vessel, in the tissues which clothe the longitudinal muscles, mesenteries, and blood-vessels, and on the inner face of the musculo-glandular tissue, of which the last-named author considers the body-wall of *Owenia* to be composed. All agree that the elements are shed into the body-cavity, that they float about in the cœlomic fluid, and are frequently found, apparently straying, in the "thoracic" and buccal segments. The means of their escape from the body-cavity is unknown, though Gilson (27. p. 370) confidently suggests that the "epithelial canal" in the second "abdominal" segment is the natural outlet. Starting from this standpoint, I have directed my attention, firstly, to observing the movements of the ova when they appear in the cephalic segment; and, secondly, to ascertain in the living animal the mode of emission of the sexual elements, and the early life-history.

By the first line of research I failed to secure the information I desired, namely, as to the fate of the ova in the cephalic segment, though it resulted in the discovery of the interesting, and probably unique structure for a Polychæte, the opening of the cephalic lobe (*c.p.*, Pl. 24. fig. 8). Although this structure is exceptional in the Polychæta, a similar prostomial pore is met with in some Oligochæta (*Enchytræidæ*), a fact to which Mr. E. S. Goodrich has kindly called my attention. Upon this point Beddard makes the useful contribution that "the dorsal pores are missing without exception in those Oligochæta which live in

water; but these latter worms have a pore upon the head, which appears to be wanting in the earthworms." He adds that "Dr. Michaelsen has thought that the head-pore serves to relieve the brain-pressure—to act in fact as a kind of safety-valve for the liberation of superfluous fluid" (26. p. 349). From what we know of the habits of the *Ammocharidæ*, it is clear that if ever such provision be needed, it would be in their case. But to continue my notes:—For several days a large Italian specimen in the desired condition was under observation, and it was noticed that the number of ova in the segment varied, increasing and diminishing, and extending even into the bases of the branchiæ, and ultimately almost entirely disappeared, without any apparent cause. Occasionally a considerable number were congregated near the centre of the groove in the cephalic lobe, and it was expected that a discharge would take place at that point, but nothing of the kind occurred. The observations and sections, therefore, simply show that, at the point indicated, there is an opening into the cœlom, guarded by a network of muscular fibres (some of which may be free, protrusible processes), and the ova may be either aerated at that point, or make their escape there under compression or when disintegrated. As to which is the more likely, I will not venture to say, though the ova which reach this spot are, apparently, so few that it cannot be supposed that all in turn pass into this segment and return to the "abdominal" segment, though this is possible. The emission of ova from the "epithelial canal" was watched for in vain; in fact, only once did a worm emerge sufficiently for its tube to expose the opening of these ducts, though, when re-burying the tubes, it sometimes happened that a sufficient length lay naked in the sand.

Fortunately, the solution came at last. On the evening of May 23rd, 1898, a large living specimen from Naples, which had settled in a small aquarium, protruded from the anterior end of its tube about 20 mm. of the posterior portion of its body, and for the space of about ten minutes discharged spermatozoa in two white, smoke-like streams, which issued from tubular openings on the ventral wall (right and left) of the anal extremity. During the discharge the animal waved its tail-end vigorously from side to side, thus assisting dispersion. The cloud of spermatozoa at first settled down, as a white layer, on the surface of the sand, but in the course of about half an hour

nearly all had disappeared. The spermatozoa (Pl. 25. fig. 19) were found to be of the form figured by von Drasche (12. pl. ii. fig. 14). Three other specimens in the same aquarium, with branchiæ fully displayed, were apparently quite unaffected by what was taking place; and this observation was one evening in the following July supplemented and confirmed by a colony of English specimens which had, a few months before, settled in another aquarium. About 7.30 p.m. several males discharged spermatozoa, the swarms of which were still close to their respective tubes, and readily recognized by the cloudy masses speedily diminishing. Shortly afterwards, several followed exactly the same course, and about the same time three females discharged ova. The latter procedure differs somewhat from the former, in that little more than the anal extremity is exposed from the anterior end of the tube. A quantity of faecal matter was first expelled, and then the ova were, as before, discharged through the two pores at the anal extremity, but much more slowly than the spermatozoa and enveloped in albumen, so that while issuing the discharge had a thread-like appearance. When deposited, there was formed a small jelly-like mass near the tube; and the contrast between the energetic movements of the male and the quiet discharge of the female was very marked. In one case a male, whilst discharging spermatozoa, actually stirred-up with his tail a mass of ova which had been deposited by a neighbour. With very few exceptions, all the worms discharged their genital products within an hour or two, and as to the cause of this simultaneous action it may be that the swarm of spermatozoa from the first animal which discharges acts as a stimulus. Hornell has observed (22. p. 13) similar synchronous emission in the case of *Branchiomma vesiculosa*.

A few days after spawning, nearly all the worms cut off about 10 mm. of the anterior end of their respective tubes. The anal pores (*a.p.*, Pl. 25. fig. 20) are very striking and interesting structures, their lumina being lined with very large, regular, radiating, cylindrical, transparent cells (*a.p.*, Pl. 24. figs. 10 & 11), which refuse stain when treated with hæmatoxylin and eosin. Possibly their function may be glandular and connected with the supply of albuminous matter, since they appear to be most fully developed in, if not entirely confined to, the females. I have been unable definitely to determine at what stage in the

animal's development these cells first appear. I have failed to detect them in the youngest specimens (only 10 mm. long), which were obtained by the kindness of Dr. Herdman from Naples; but I found them fairly well developed in other specimens (only 16 mm. long) which, though probably only a few weeks older, were full of ova. In order to reach these pores, the genital products pass through the sphincter septal valves (*s.v.*, Pl. 23. fig. 5), which can easily be traced in the sections right up to the lumina of the pores. On one occasion, whilst examining a preserved *Ammochares* from Naples (which in 90 per cent. alcohol had not become hardened), I accidentally caused these pores to open and work by osmotic action, the specimen having been transferred to spirit of a different strength.

The ova, deposited on the 17th July 1898, were examined every 24 hours and sketched from life from the 19th to the 21st inclusive (Pl. 25. figs. 14-18). On the second day, the eggs were in the morula stage, and a few specimens, which had been transferred from the aquarium to a small glass dish, had, on the 20th July, attained the two different forms represented by figs. 15 & 16, Pl. 25.

In view of the subsequent development, it is interesting to note that, whilst watching the specimen fig. 16, I observed, now and then, a thread or two, with a cell at the extremity of each, shot forth from the point (*m'*), the threads being immediately retracted. Fig. 15 is also deserving of special attention, since it corresponds, most closely and suggestively, with a stage in the development of the Hydrozoa, as shown in Fewkes' figure of *Agalma* (11. pl. iii. fig. 12) of somewhat similar age. It was found that development had been retarded by removal, as specimens taken the same evening from the aquarium had reached the stage with characteristic setæ, fig. 17, which will be recognized as *Mitraria*. On the following evening, the specimens in the glass dish were found dead, and those in the aquarium, although vigorous, had apparently made little or no further progress in development. The larva attached itself by its setæ to the bottom, and, using them as a pivot, rotated in a top-like fashion in the watch-glass, whilst four others, affixing themselves by the same means to a speck of floating organic matter, in the form of a cross, caused it to revolve like a miniature wheel. This rotation was doubtless due to cilia at the apex of the bell, as the motion of those at the margin was scarcely perceptible.

When making my sketches, I had neither seen Metschnikoff's nor any other figures of *Mitraria*, and I had constantly to wait until the animal returned to its original position: to this fact is due the omission in fig. 18 of the two crescent-shaped thickenings of the epidermis figured by Metschnikoff (7. pl. xviii. fig. 8), as although they were seen distinctly when drawing other parts, no subsequent view enabled me to give their exact form and position.

Upon comparing the figures (17 & 18) with those of Metschnikoff (7. pl. xviii. figs. 5 & 8), the chief difference relates to the outline of the ciliated margin of the hydrophyllium; that of my specimen was perfectly plain, and, when seen from below, somewhat oval in outline, whilst Metschnikoff's figures show the margin to be deeply lobed. That Metschnikoff's *Mitraria* is the larval form of a species of *Ammochares* there can, I think, be little doubt. Its agreement with that of the English form, *Owenia*, is exceedingly close.

The lingual organ of the young worm, figured by Metschnikoff (7. pl. xviii. fig. 12), agrees closely, both in form and position, with that of *Ammochares*, whilst the position of the "schleimabsondernde Organe" corresponds with that of part of a "thread-gland." The form of the uncinus (7. pl. xviii. fig. 12A) is unmistakably that of the family, though Metschnikoff's figure of the worm (7. pl. xviii. fig. 12) shows only a *single* row of uncini to each of the "abdominal" segments. The anterior smoothly truncated end of the worm, shown in his figure, corresponds with what might be expected from Cunningham and Ramage's observation (15. p. 656) that, "in small specimens the mouth is surrounded by a funnel-shaped lip, quite entire, except for a ventral notch," and that "it is only in the larger specimens that the branched processes are seen." Metschnikoff's statements (7. p. 241) that while each of the first three segments of his young worm bore on either side a bundle of fine tapering setæ only, all the other segments were equipped with both setæ and transverse rows of uncini; that the first eleven segments were extraordinarily long, and distinguishable only by the arrangement of the bristles, since the usual segmental cross-furrows were absent; and that the last body-segment ended with two roundish little lobes, between which was the anal opening (points all in striking agreement with the structure of the Ammocharidæ), convey, in combination with his figure, what



apparently is an accurate description of a young *Ammochures*. It will doubtless be admitted that these facts completely refute the suggestion of Häcker (31. p. 15), based mainly upon the form of the bristles, that *Mitraria* should be regarded as related to the *Hermellidæ*.

Further study of the early stages of development will certainly yield an ample reward. The imperfections of the present account are largely due to the fact that I was striving to rear the larval forms, and consequently hesitated to kill any of the specimens. My observations were made in the summer of 1898, and, unfortunately, the efforts which I made in the two following years proved abortive.

The Ammocharidæ have a very extended range, viz., the Arctic Ocean (Spitsbergen), North Sea, Mediterranean, Adriatic, Davis Straits, the Antilles, Brazilian seas, Japanese seas, and the Philippines.

De Saint-Joseph (29. p. 404) has called attention to their connection with the Maldanidæ on the one hand, and the Serpulidæ on the other; whilst Gilson has emphasized many of the interesting points in their structure, and argues (30. p. 90) that the absence of muscular rings from the greater part of the body and the existence of the two longitudinal mesenteries are characteristics of inferiority, and recall the Archiannelids, a contention which, adopting Meyer's view of "Annelid Descent" (18 b. p. 1147), appears to be supported by the discovery of the anal outlets for the genital products, and also by the exceptional larval forms.

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arranged in order of appearance.

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## EXPLANATION OF THE PLATES.

## Reference Letters.

*a.*, anterior extremity. *a.p.*, anal pores. *b.*, brain. *b.t.*, branchial tentacles. *b.w.*, body-walls. *c.*, collar. *ch.*, bristle-bearing process. *c.l.*, cephalic lobe or crescent. *c.m.*, circular muscles. *c.p.*, cephalic pore. *c.t.*, conical tip of tube. *d.c.*, intestine. *e.*, eye-spot. *æ.*, œsophagus. *e.c.*, epithelial canal. *f.s.*, fragment of stone or shell. *f.v.*, flap-valve. *h.b.*, epidermal band. *h.c.*, high cells of Lippen-organ. *l.*, under-lip. *l.c.*, shorter cells of Lippen-organ. *l.l.*, lateral lobe. *l.m.*, longitudinal muscles. *l.o.*, Lippen-organ. *l.r.*, upper-lip. *m.*, mouth. *m.t.*, membranous tube. *p.*, posterior extremity. *s.*, setæ. *s.c.*, stony covering of tube. *sp.*, septum. *s.v.*, sphincter valve. *t.*, torus. *t.g.*, thread-gland. *t.p.*, thoracic pouch. *t.v.*, "thoracic" septal valve. *u.*, uncini. *v.a.*, thin ventral "thoracic" area.

## PLATE 23.

- Fig. 1. Diagrammatic section of *Ammochares*, illustrating method of forming the imbricated tube.
2. *Ammochares filiformis*. Cephalic segment viewed from above, showing the internal lobes (*c.l.* & *l.l.*) as they would appear during life. This is a restoration of fig. 3.
3. *Ammochares filiformis*. Cephalic segment viewed from above (von Drasche), showing the "Lippen-organ" (*l.o.*) and mouth (*m.*), which are frequently visible after death owing to contraction of the three lobes.
4. Uncini of *Ammochares* :—  
*a'*. *Ammochares assimilis*, Sars (4. Pl. xii.).  
*b'*. " *ottonis*, Grube (5. Pl. xv.)  
*c'*. " *fusiformis*, D. Chiaje (29. Pl. xxii.).  
*d'*. Uncinus of *Mitraria*, Metschnikoff (7. Pl. xviii.).
5. Diagrammatic vertical section of a posterior segment of *Ammochares*, showing the action of the septal valves (*f.v.* & *s.v.*).
6. Dorsal view of second "abdominal" segment of *Ammochares*, showing the zigzag epithelial canal (*e.c.*) in the lateral bows; also (in dotted outline) the form and position of the thread-glands.

## PLATE 24.

- Fig. 7. Vertical longitudinal section of anterior extremity through centre line of *Ouenia filiformis* (English), showing, ventrally the "Lippen-organ" (*l.o.*) *in situ* when at rest; and dorsally the cephalic lobe, with indication of cephalic (præstomial) pore (*c.p.*).  $\times 45$ . (From a thick section.)

- Fig. 8. Vertical longitudinal section through centre of cephalic lobe, showing the brain (*b.*) and cephalic (prostomial) pore (*c.p.*) with its transverse muscular fibres. *Ammochares filiformis* (Naples).  $\times 100$ .
9. Transverse section of ventral end of "Lippen-organ," showing the tall, clear secreting-cells (*h.c.*) and the underlying folded structure (*l.c.*). *Ammochares filiformis* (Naples).  $\times 100$ .
10. Horizontal section through the anal lobes and pores (*a.p.*) of *Ammochares filiformis* (Naples). A deep section, showing the internal radiate arrangement of cells lining the pores.  $\times 100$ .
11. Horizontal section, showing glandular structure of cells and lumina of anal pores (*a.p.*). *Ammochares filiformis* (Naples), ♀.  $\times 100$ .
12. Anterior or exposed end of tube, showing the clear elastic tip of inner sheath, and the imbricated arrangement of the external stony covering (*s.c.*). *Owenia filiformis* (English).
13. Posterior or buried membranous end of tube of *Owenia filiformis* (English), showing its telescopic construction and consequent external stepped appearance; also the strengthening of the wider part by external disc-like additions (*d.*).  $\times 22$ .

## PLATE 25.

Figs. 14, 15 & 16.—Stages in the development of the larva of  
*Owenia filiformis*.

Fig. 14. The embryo 48 hours after discharge of ova.

15. " 72 " "

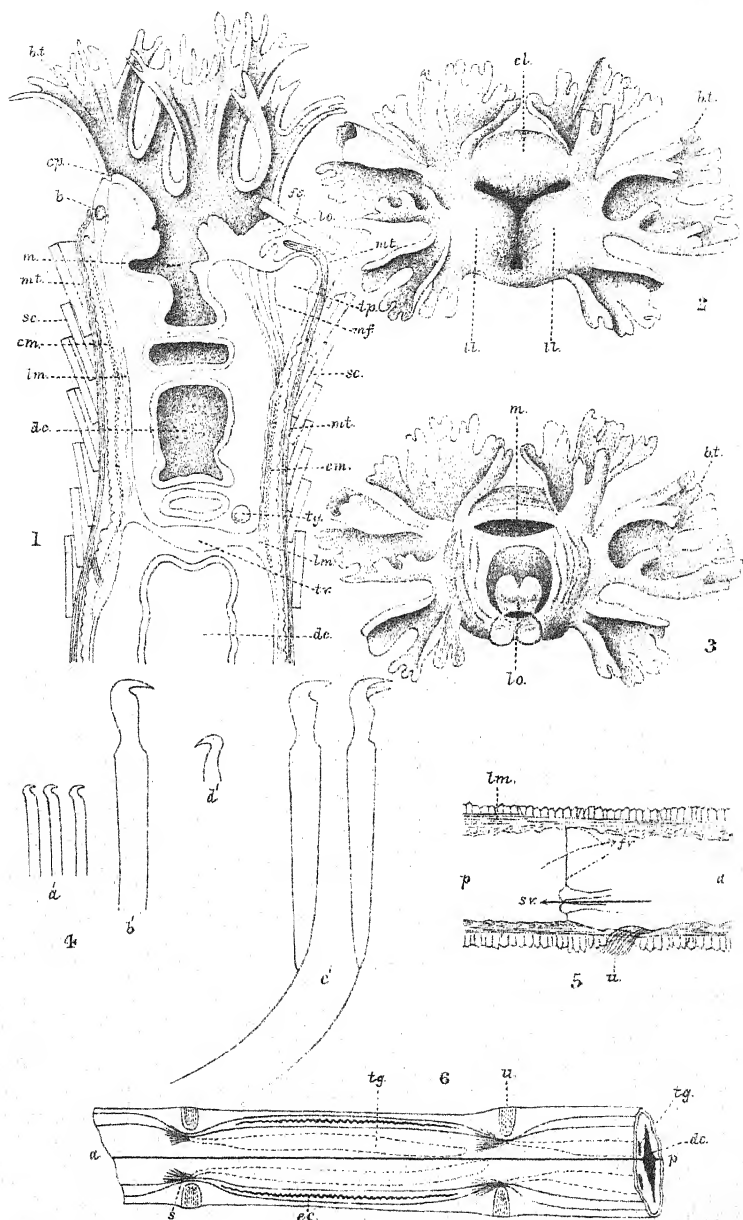
16. " 72 " "

17. Larva of *Owenia*. Lateral view 96 hours after discharge of ova  
= *Mitraria*.

18. The same, viewed from beneath.

19. A ripe spermatozoon of *Owenia*.

20. *Ammochares filiformis* (Naples). Ventral view.  $\times 2$ . (From a preserved specimen.)

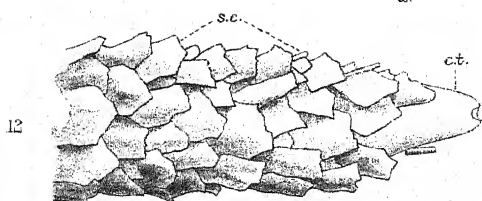
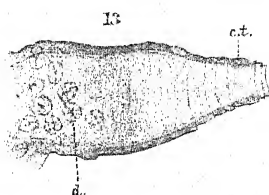
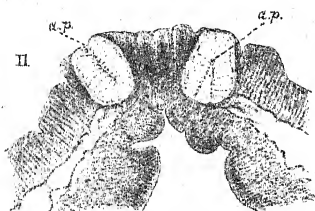
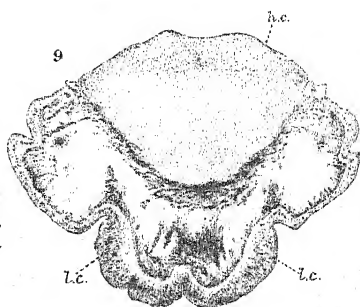
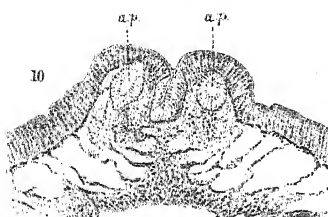
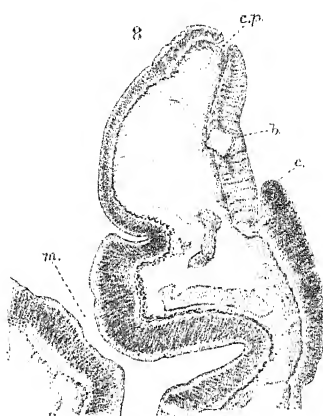
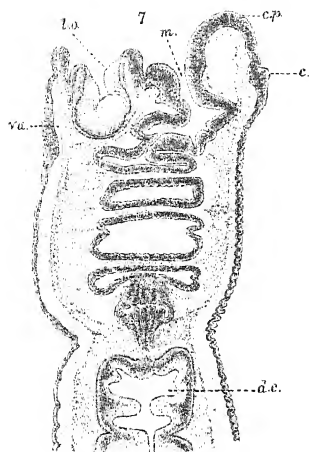


A.T.W. del.  
M.P. Parker lith.

Parker & West imp.

# STRUCTURE OF THE AMMOCHARIDA.





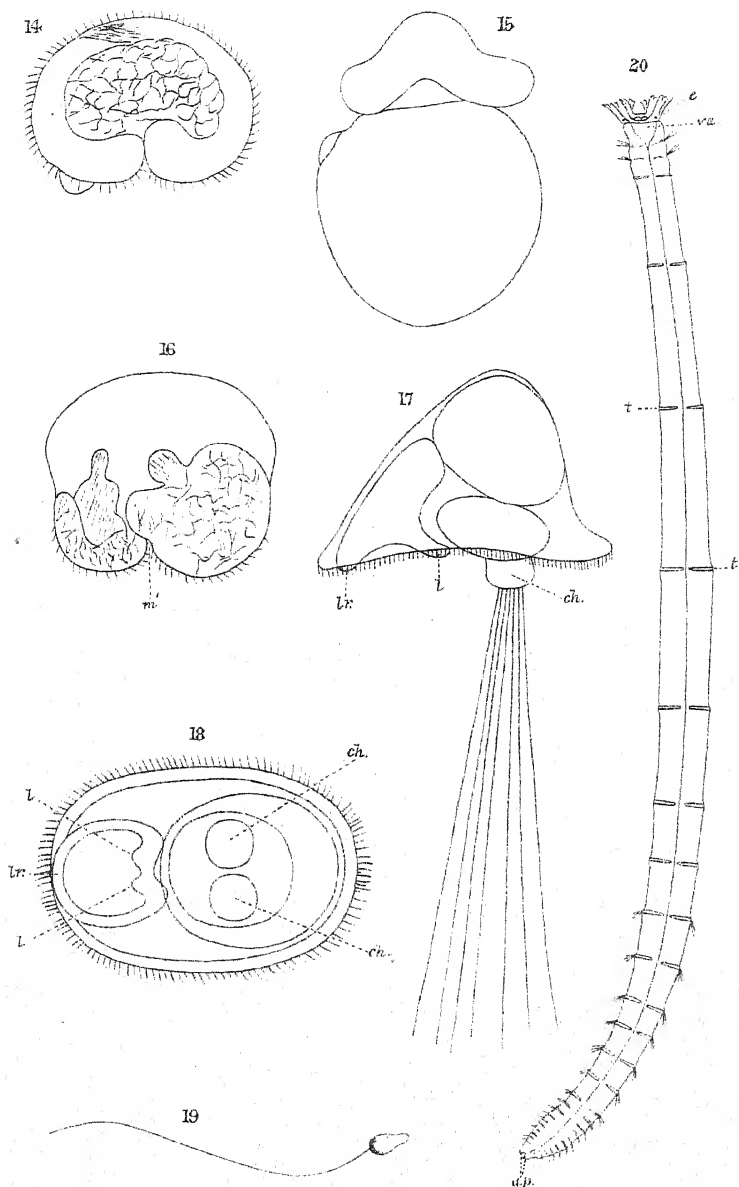
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# STRUCTURE OF THE AMMOCHARIDÆ.







A. T. W. del.  
M. P. Parker lith.

Parker & West imp.

AMMOCHARES & DEVELOPMENT OF OWENIA.



TOOTH-GENESIS IN THE CAVIIDÆ. By H. W. MARETT TIMS, B.A., M.D., F.L.S., F.Z.S., Lecturer on Biology and Comparative Anatomy, Charing Cross Hospital Medical School; Lecturer on Zoology, Bedford College, London.\*

[Read 17th January, 1901.]

(PLATE 26.)

THOUGH much has been already written concerning the dentition of the Rodentia, no paper has yet appeared, so far as I am aware, dealing with the tooth-genesis of that Order. Previous research has been mainly, if not entirely, in the direction of attempts to discover the germs of teeth no longer functional in the adult, more particularly in the region of the diastema and premaxilla, and thereby to endeavour to homologize the existing incisors of the Rodents with those of other mammals.

The morphological value of an enquiry into the tooth-genesis is due to the fact that several views have been advanced from time to time to account for the origin of the complex crown of the mammalian molars from the Haplodont type of tooth.

In 1896, in a paper dealing with the tooth-genesis in the *Canidæ* [22], I adopted the suggestion of Forsyth Major that there was the possibility that the Rodentia may have been derived from the Multituberculata, even though the teeth of the Dogs could not be so derived. I was led to do this mainly for two reasons:—(1) the similarity between the dentitions of the Multituberculata and the Rodentia; and (2) the value of the Palæontological evidence collected by Dr. Forsyth Major and published by him in numerous papers. It was therefore with the object of testing the validity of this suggestion from the embryological standpoint, that I commenced this research, the results of which are here set forth.

The selection of *Cavia* as an animal upon which to work was chiefly due to the fact that my friend Mr. Martin F. Woodward had very kindly given me a series of fœtal Guinea-pigs. Upon this material ready to hand, I commenced the investigation. I have also examined specimens of fœtal rats, mice, and rabbits (with which I hope to deal more particularly in the future). These, though showing differences in detail, nevertheless appear to me

\* From the Morphological Laboratory, Cambridge.

to confirm the conclusions upon the broader issues with which I am here mainly concerned. If my identification of the individual teeth in *Cavia* be correct, it then follows that the identification usually accepted of the teeth of the Rodents in general may in many instances be incorrect. This being so, I have deemed it advisable to limit myself, in the present instance, to the teeth of the *Caviidæ*, and not to deal with the Order as a whole as was originally my intention.

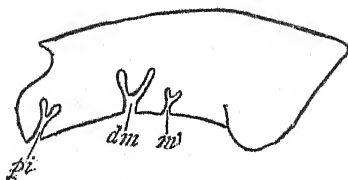
The method I have followed has been that of cutting and examining serial transverse sections of the jaws, after staining in bulk. In some cases the stain used has been borax-carminé; in others Tomes's ferric-perchloride and tannic-acid method was adopted. The jaws were decalcified in a 2 per cent. solution of each of the following, viz.:—hydrochloric acid, nitric acid, and ferric perchloride. The object in using a combination of the two acids being to neutralize the shrinkage of the tissues caused by the former by the swelling caused by the latter. After decalcification, the iron in the tissues was reduced by a 3 per cent. solution of tannic acid. Wax models of the younger stages of the teeth have been made, while in the older the teeth were examined *in situ* by clarifying the jaws in oil of cloves.

I shall commence with a detailed description of each stage, comparing my results in each case with those of other writers, and will leave a general consideration of the problems involved to be dealt with in the latter part of the paper.

#### CAVIA COBAYA.

Stage 1. Circumferential head-length..... 1.5 cm.  
 „ body-length ... 4 cm.

Fig. 1.



Reconstructed diagram, showing the number and position of teeth present in Stage 1. *pi*, permanent incisor; *dm*, deciduous molar; *m*<sup>1</sup>, first molar.

In this, the youngest stage examined, rudiments of three teeth were to be found in the upper jaw, none, however, showing any traces of calcification. The three teeth present are the incisor,

the deciduous molar, and the molar immediately behind it, the two latter being usually interpreted as *dpm.1* and *m.1*, but which, as will be seen subsequently, I believe must be regarded in a somewhat different manner. The enamel-germ of the upper incisor has assumed the characteristic bell-shape. There is a decided labial downgrowth of the dental lamina (Pl. 26. fig. 5), which is, I believe, to be regarded as the vestigial remains of the deciduous incisor. That it cannot be looked upon as affording evidence of a pre-milk dentition is clear from an examination of the later stages, the bell-shaped germ of this stage growing continuously to form the permanent incisor of the adult. This labial downgrowth is also extremely well marked in the case of the lower incisors. I was not able to detect any trace of a tooth anteriorly or posteriorly to this in the incisor region in the upper jaw. Throughout the several succeeding sections the dental lamina can be traced definitely running through the diastema, but without any indications of enamel-germs. It then dips deeply into the substance of the jaws both upper and lower, and gives rise to a well-marked enamel-germ. This germ has slight traces of both labial and lingual downgrowths in the upper jaw; while in the lower jaw the latter only is present, but more distinct than is the case with the corresponding process in the upper jaw. From a consideration of the reconstructed diagrams of this and the subsequent stages, I think it will be evident that this is the germ of the deciduous tooth. From the wax model it is seen to consist of a cone surrounded by a cingulum. The latter structure projects to form a very definite upwardly-directed and somewhat pointed process arising from the inner side of the main cone. There is a corresponding, though less pronounced projection on the outer side. Some little distance behind this tooth the dental lamina again becomes distinctly enlarged at its deeper extremity, forming a flask-shaped mass, as yet not invaginated by any appearance of the dental papilla. No further trace of any germ is visible at this stage.

With regard to the labial downgrowth of the dental lamina in connection with the functional incisor, which I have represented (Pl. 26. fig. 5), it is interesting to compare it with the condition found in other Rodents. Huxley was the first [12] to note the existence of minute milk predecessors to the large functional incisors in the rabbit. This discovery has been verified by Pouchet & Chabry [14], Freund [10], and Woodward [27].

Writing in 'Nature' [11], referring to these vestigial teeth, Huxley pointed out that "it would be interesting to examine fetal guinea-pigs in relation to this point; at present they are known to possess only the hindermost deciduous molars, so far agreeing with the marsupials." Freund [10] has also discovered the existence of vestigial milk-incisors in the squirrel in both jaws. Though he inclines to the belief that these vestiges are to be interpreted in this manner, yet he implies the existence of some doubt. From his description of the connection between the neck of the permanent teeth and that of the vestigial teeth, and from the fact that the rudimentary enamel-germ and the large incisor are included in the same thickened connective-tissue capsule, I think there can be little doubt but that they are vestigial milk-incisors, and that Freund, as Woodward says, is "over-cautious and inclined to underestimate the facts which suggest that condition." Again, Mr. M. F. Woodward (*l. c.*) has described in the mouse "a pair of very minute calcified tooth-rudiments in connection with the two large upper incisors, one each side of the jaw." These rudiments he considers to represent "the last stage in the reduction of a vanishing tooth, the earlier stages of which are to be seen in the rabbit and squirrel." The guinea-pig will thus be seen to add a still further stage in the degeneration of this tooth, forming a very complete and interesting series.

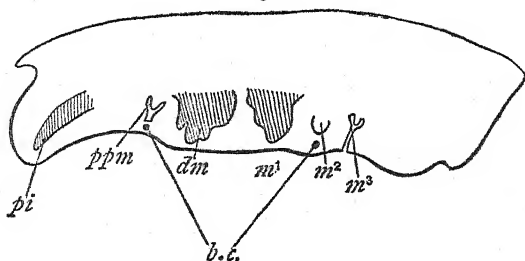
Two observers, Freund [10] and Adloff [1], have also examined specimens of *Cavia* at this stage; their measurements differ considerably from my own, and possibly the discrepancy may be due to the method of measuring: as I estimated the length from the tip of the snout to the root of the tail circumferentially, this would obviously give a greater length than if measured in a straight line. Freund has also examined two younger stages, the earlier one having a cephalic length of 4.5 mm., the measurement of the other not being given. This writer gives but few details as to the condition found in these three young stages, merely stating that he found no trace of a germ for the second incisor, and nothing in the diastema beyond a few thickened cones of epithelium, which he could not satisfy himself were to be regarded as tooth-rudiments. Adloff, on the other hand, gives more details of the examination of his specimens at this stage, and accompanies his description by three figures. His description of the tooth which he identifies as *Pd.3*

corresponds with the first cheek-tooth of my specimen, except that he mentions and figures a lingual downgrowth only, whereas in mine both lingual and labial downgrowths were present in the upper jaw, but only the former in the lower. This point is, I think, worthy of mention, for the reason that I have already [22] expressed my adherence to the current belief that the upper jaw retains the more primitive condition. In neither of these cases is the labial downgrowth present in the lower jaw, while in the upper it is present in the one case and not in the other. The conclusion appears to me to be that this labial downgrowth has already ceased to exist in the lower jaw, while in the upper jaw it is in the process of disappearance. The lingual downgrowth is present in both upper and lower jaws in Adloff's specimen as well as in my own. In this I think one may find further confirmation of the view that the dentitions present in the Mammalia tend to disappear from without inwards.

Adloff makes no mention of any indication of the incisors, which are well marked in my specimen. He also says that *m.1* and *m.2* were not yet to be found; whereas *m.1* was present in mine as a flask-shaped non-invaginated mass, *m.2* not being indicated. Possibly mine may have been a slightly older specimen, which would not invalidate, but rather strengthen, the deductions I have drawn.

Stage 2. Circumferential head-length ..... 2.7 cm.  
 „ body-length ..... 7.5 cm.

Fig. 2.



Reconstructed diagram of Stage 2. *pi*, permanent incisor; *ppm*, permanent premolar; *dm*, deciduous molar; *m<sup>1</sup>*, first molar; *m<sup>2</sup>*, second molar; *m<sup>3</sup>*, third molar; *b.e.*, "concentric epithelial bodies."

The incisors are now teeth of considerable size and curve backwards deeply in the substance of the jaw. They are well-calcified,



but the enamel appears to be deficient on the posterior surfaces. No trace of any downgrowth, lingual or labial, is visible. Some distance from the anterior end of the jaw, in a position posterior to where the permanent incisor cuts the gum, the dental lamina grows deeply into the substance of the jaw; it persists through some sections and then ceases, it is bilaterally symmetrical. Possibly this may mark the position of *i.2*, which has disappeared.

Throughout the diastema no trace of any tooth-germs is visible. The most anterior cheek-tooth is the so-called *ppm.1*, it is in a somewhat rudimentary condition and as yet quite uncalcified. It consists of a single cone with a blunted summit. The internal cingulum is present, and also indications of an external. I would here specially note the presence of a spherical body, composed of concentrically arranged cells, lying in the line of the connecting neck of dental lamina (Pl. 26. fig. 9). I have already figured [22] a precisely similar structure in connection with *pm.4* of the dog, the only difference being a slight one of position. In the latter case, it lies at the free extremity of a labial downgrowth of the dental lamina; whereas in the present instance, it is directly in the line of the dental lamina running between the oral epithelium and the tooth. In the guinea-pig this structure is present on both sides of the upper jaw, and persists for some time. A similar structure is also to be found in connection with the so-called *m.2*. I have already referred (*loc. cit.*) to the fact that Mr. M. F. Woodward has found a similar structure in *Gymnura* in the same position, viz., in connection with the posterior premolar.

In discussing the question, I there stated that I was not able to give an explanation of the condition, "but from the fact of its connection with the dental lamina and its presence in precisely the same situation in these forms" (i. e. *Canis* and *Gymnura*) "I do not think it is a chance structure, and it is possible that it may represent the remains of a predecessor to this tooth." From a further consideration of this point in *Cavia*, I am still more inclined to this opinion. Mr. Woodward has figured a calcified vestigial incisor in the mouse [25] which, as he describes, appears in section "as a narrow loop forming about  $\frac{3}{4}$  of a circle, a few of the mesoblast-cells having flattened themselves against the outer surface of the dentine." From a comparison

of the two conditions, it is easy to imagine that a still further stage of degeneration would give the appearance seen in the dog, guinea-pig, and *Gymnura*.

Just as the rudimentary germ of the premolar is on the eve of disappearing, the tooth immediately behind it, the so-called *dpm.*, is commencing to appear, but placed much more deeply and lying altogether underneath the preceding tooth. Tracing it backwards, it is seen to be well-calcified, but has not yet reached the surface of the gum. No labial or lingual downgrowths are to be seen, though traces of both have been noted in Stage 1. There is an interval of 70 sections between the neck of this tooth and that of the preceding: consequently I think there can be no possible morphological connection between the two. If such be the case, then these two teeth can no longer be regarded as the morphological predecessor and successor, the one of the other. I believe the correct interpretation to be that the more anterior tooth is a premolar, probably *pm.* 4, belonging to the successional series, and the so-called *dpm.* is the first true molar. The reasons which lead to this conclusion will be discussed below. I shall therefore in what follows speak of the five teeth in the upper jaw of the guinea-pig as *pm.* 4, *ms.* 1, 2, 3, 4.

The deciduous tooth at this stage (Pl. 26. fig. 1) possesses two antero-posterior rows of cusps, and has the appearance of two similar portions one behind the other, the anterior being the larger. This remark applies to all the cheek-teeth both at this and later stages; and for this reason I think there is a possibility of the correctness of the Concrecence theory. The external row has three distinct cusps, of which the centre one is the more pronounced and the posterior slightly smaller than the anterior. The internal row also consists of three cusps, the anterior being the largest. The middle cusps of the two rows are separated one from the other by a wide depression; while the first and third cusps of both rows are connected respectively by ridges which bound the depression anteriorly and posteriorly. Behind the posterior ridge is a second smaller depression separating the outer from the inner posterior portions of the tooth which do not possess any definite cusps. The anterior and central cusps form the anterior larger portion of the tooth; the third cusps with the posterior portion of the tooth together forming a miniature of the anterior part. The first and third cusps of the external row are

slightly undermined at their bases, representing the involution of enamel which is carried to such extremes in the teeth of some other Rodents.

The second molar, or second cheek-tooth of the adult dentition, resembles the anterior part of the tooth just described. There are two external cones, the posterior being of considerable size, the anterior inconspicuous, and the same may be said of the two internal cusps. The antero-internal and antero-external cusps are partially fused with each other transversely, whereas the two posterior cusps are separated by a deep but narrow cleft (Pl. 26. fig. 3). The posterior part of the tooth is made up of a mass of considerable size with a rudiment of a cusp, both internally and externally, the latter being slightly the larger. At the base of the tooth, on both its outer and inner aspects, is a well-marked rounded prominence which I think must be regarded as the cingulum.

The third molar is not calcified. It presents a broad, transversely elongated surface with an external and an internal cusp, the former being the larger. There is a well-marked lingual downgrowth of the dental lamina. In connection with this tooth there is one of the concentric epithelial bodies to which I have already referred.

If these bodies really do represent the last stage in the disappearance of a tooth, we have here in connection with an undoubted molar tooth evidence of three dentitions, from the central one of which the permanent tooth develops. Adopting the line of argument I have previously used when referring to the Marsupial dentition [21], it would seem to show that the molar teeth do belong to the successional series—a view which, though held by many, is not universally accepted. The fourth molar is present in a very rudimentary condition.

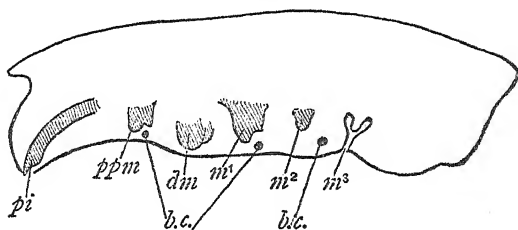
The second, and last stage of *Cavia cobaya* examined by Adloff had a head-length of 3 cm. This measurement corresponds exactly with my Stage 3; but from the description given, it is evident that Adloff's was a much younger specimen, the difference being no doubt due to a difference in the method of measuring. From a comparison of the results, I am inclined to think that his specimen must have been slightly younger than my Stage 2. He finds that the first "Anlage" in the hinder portion of the jaw is that of the premolar of the first dentition, that is of the deciduous tooth. This is in agreement with what I have found

namely, that this tooth commences to develop earlier than the tooth in front of it, which I believe to replace it.

In connection with *m. 2* he describes and figures both lingual and labial downgrowths of the dental lamina; the latter he interprets as a pre-milk vestige. This interpretation I shall discuss subsequently. The posterior molar (*m. 3*) he states is not at this stage developed.

*Stage 3.* Circumferential head-length..... 3 cm.  
 „ body-length..... 9.3 cm.

Fig. 3.



Reconstructed diagram of Stage 3. Lettering as before.

The incisors are now large teeth which have just cut the gum. No trace of any vestigial tooth is to be seen, here or in the diastema.

The first cheek-tooth is well-developed though not calcified. The "concentric epithelial body" is clear and distinct. It appears to occupy a similar position relative to the edge of the jaw as in the previous stage; but the tooth with which it is connected is now more deeply placed. Its connection with the surface being severed, the relative position of the "concentric epithelial body" to the neck of the enamel-germ can no longer be definitely ascertained. The tooth itself is transversely elongated, its axis in this direction being double that of the antero-posterior axis. Excluding the internal and external cingula, representatives of two antero-posterior rows of tubercles are present about the centre of this tooth, as is seen in Pl. 26. fig. 2. Of these, the outer is more pronounced, and becomes the antero-external cone of the adult tooth. The second cusp from the outer side is the second largest; it attains its maximum at a point in a plane slightly posterior to that of the principal cone, where the latter is gradually shelving upwards. In the posterior

part of the tooth these two cones are indistinguishable the one from the other, having fused to form a solid mass. The second cheek-tooth (Pl. 26. fig. 4), which is the deciduous tooth, is well calcified, and on the verge of cutting the gum. It consists of a large antero-external cone, the apex of which has an elongated cutting-edge, still showing indications of two tubercles. On comparison with the model of this tooth at the previous stage, this cone appears to be formed by a fusion of the anterior and central external cusps. The well-marked median internal cone of the earlier stage has now entirely disappeared. The postero-external and postero-internal cusps are relatively much smaller. Owing to the greater size of the tooth, the excavation of the posterior part of the tooth in a forward direction appears to be more pronounced. On the other hand, the undermining of the base of the antero-external cusp from within outwards, previously mentioned, is now scarcely perceptible. No marked trace of the external cingulum is present either in this or the preceding stage.

Microscopically, the epithelial neck of the tooth-germ is no longer visible; and I have not been able to detect any lingual downgrowth such as would suggest that this tooth had any morphological successor.

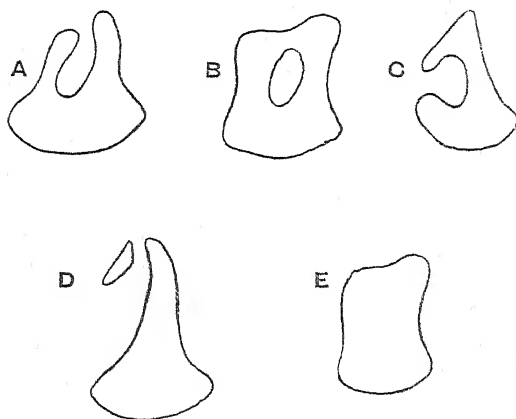
The condition of the third cheek-tooth has become complicated by the presence of infoldings of the enamel. Here again, there is a large external cone which has to the outer side of its base two minute cusps, which I consider as belonging to the external cingulum. The well-marked inner cone, described in the preceding stage, appears to have fused by its apex with that of the external cone, the two being separated at their bases, giving in section the appearance of an elongated foramen. It might be thought that this foramen was due to the tunnelling forwards of the substance of the tooth from its posterior end, such as was found in the second cheek-tooth. Such, I believe, cannot be the cause, for two reasons: (1) in the previous stage no trace of any tunnelling is observable; and (2) the external and internal cones are separated by a deep fissure extending down to almost the root of the tooth. This foramen seems, therefore, to be due to a fusion of the apices of the two cones cutting off the deeper part of the fissure from the surface. This occurs towards the anterior part of the tooth. About the centre a communication takes place between this cavity and the internal surface of the

tooth, separating the internal cone from its base; and as this detached portion is fused by its apex with the external cone, the tooth in section has the appearance of an inverted V, the external limb of which is considerably longer than the internal. How this communication is brought about, whether by the rupturing inwards of the central cavity, or by the extension into the latter of a channel running outwards from the internal surface, I am not in a position to say.

If the condition of this tooth be traced still further backwards, the communication is still seen to be present; and, in addition, the central cavity communicates with the surface, the apices of the external and internal cones being separated. This may have been brought about by the formation of a cleft from without inwards, or from within outwards; or, what I think the more probable is, that the apices of the two cones have here remained separate, not having undergone fusion, as in every instance the posterior moiety of the tooth seems to be in a somewhat earlier stage of development than the anterior.

In a section through this region, the apex of the internal cone

Fig. 4.



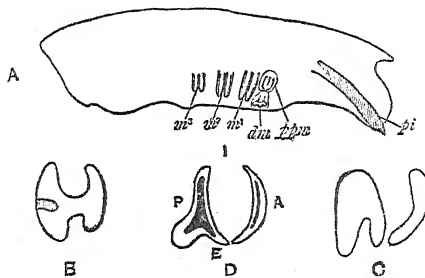
Diagrammatic sections through Third Upper Cheek-tooth. A from Stage 2.  
B, C, D, E, from Stage 3.

lies as an isolated mass to the inner side of the external, the latter retaining its connection with the fused bases of the two cones, appearing almost identical in section with that through the centre of the deciduous tooth. This I regard as being a



gum, somewhat to its lingual side. The anterior cheek-tooth of the adult consists of two plates, an external and an internal, separated one from the other by a deep oblique cleft, so deep that the plates are but slightly connected by their bases and are easily separable. The position of the tooth is partially rotated through an angle of about  $45^\circ$ , so that the external and more prominent cone lies antero-externally, the internal being postero-internal. When examined from the internal surface, the apex of the outer cone appears to be folded inwards so as to reach the apex of the internal cone, but without being fused with it. The folding gives rise to a transverse groove crossing the apex of the external cone.

Fig. 5.



- A. View of teeth in Left Upper Jaw (Stage 4), seen from the inner side.  
 B. Crown surface of Deciduous Tooth.  
 C. " " Successional Tooth.  
 D. " " Fourth Cheek-tooth.

The inwardly-folded apex is supported by a vertical ridge upon the inner face of the external cone, so that this cone would on horizontal section have a triangular shape, the curved base being external, the apex internal with a slightly backward inclination, which is applied to, but not fused with, the outer face of the internal cone towards its posterior margin, as seen in fig. 5 C. It lies in a separate capsule of its own, quite distinct from that of the deciduous tooth, which is nearer the margin of the gum. The latter has not undergone any rotation, is very minute and its cusps complete, the enamel not having disappeared from their apices.

The third and fourth cheek-teeth had already assumed the characters of adult teeth, the former being the larger.

With regard to these teeth, I would note the absence of tubercles from the crown-surface, the enamel having partially



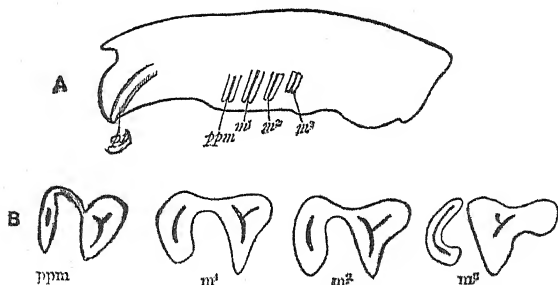
disappeared even though the teeth had not cut the gum. This confirms the observation made by Saint-Loup [18], which led him to ask the question whether this is a case of the hereditary transmission of acquired characters, since it cannot be due to wear.

The posterior tooth is much smaller; its characters I was not able definitely to ascertain owing to its position and the difficulty of dissecting it out from its osseous surroundings.

The surface view of the deciduous tooth is seen in outline in fig. 5 B; a comparison of this with the teeth shown in Pl. 26. figs. 7 & 8 is, I think, suggestive, the same general pattern being noticeable: more particularly is this the case on comparison with the tooth of *Stichomys* of the Lower Eocene; the latter is, however, slightly more complicated. This fact may afford some additional argument in favour of the multituberculate origin of the Rodent molars.

Stage 5 (*Post partum*). Circumferential head-length 5 cm.  
 „ body-length 12 cm.

Fig. 6.



A. View of teeth in Left Upper Jaw (Stage 5), seen from outer side.  
 B. Crown-surface of permanent premolar and three molar teeth.

Examination of the clarified jaw shows the presence of four cheek-teeth only, all traces of the deciduous molar having disappeared. Of these teeth the second is the largest, and is the only one in addition to the incisor which has actually cut the gum. All have assumed the characteristics of the adult dentition. The enamel is absent from the crown-surfaces, all trace of definite cusps being wanting. A side view of the teeth *in situ* is shown in fig. 6 A, while the crushing surfaces are represented in fig. 6 B.

Having now given an account of the conditions found in these various stages, the question arises as to what interpretation may be placed upon them. In the first place, it will be noted that the deciduous tooth is the first to arise, or at least is the more advanced in the first stage examined. In tracing its subsequent development, it does not appear to be connected with any germ which could be interpreted as either a predecessor or a successor: in other words, this tooth seems to be represented in one dentition only, and it might be either a milk-tooth the successor of which had become suppressed, or *vice versa*; and I know of no definite data upon which to form a decided opinion. The fact of its early appearance, and of its being shed *in utero*, might seem to favour the former alternative. I am inclined, however, to regard it as a permanent tooth accelerated for the following reasons:—(1) its development is but little in advance of the incisor or of the molar immediately behind it, both of which are known to belong to the second dentition; (2) in the dog the carnassial tooth of both dentitions is developed in advance of the other teeth, which supports the view that teeth in this position have a tendency to become accelerated; and (3) I believe that the dentitions in the Mammalia tend to disappear from without inwards.

This being so, I would regard all five tooth-germs found in the guinea-pig as belonging to the permanent series, the first and fourth having, in my opinion, vestigial remains of milk predecessors in the "concentric bodies" afore described (Pl. 26. fig. 7).

Though the pattern of the so-called molars and premolars in the adult *Cavia* are practically identical, still in their earlier stages they are somewhat different, the anterior cheek-tooth being transversely broader and more multituberculate than the posterior ones. The deciduous tooth appears to me to partake more of the nature of the latter; and I am inclined to believe that it is to be regarded as the anterior molar, thus agreeing with the suggestion first made by Woodward in relation to other mammals.

The tooth which replaces the deciduous is the anterior cheek-tooth, which is not therefore its true morphological successor, but merely drops backwards and occupies its position.

In this connection it is interesting to note what Forsyth Major says [8] in referring to *Prolagus sardus*:—"The anterior of the three deciduous teeth is not situated directly above the

anterior premolar, but slightly backward, closely appressed to the second deciduous, so that with its anterior moiety it covers only the posterior part of the premolar; besides it could not possibly cover the latter completely, being much smaller." And, as he points out, Fraas [9] states that the anterior premolar in *Prolagus* has no deciduous predecessor, but that it "comes into place through the same lacuna." Clearly, then, this is not a unique condition in the Rodents, and I have referred [22] to what I believe to be a somewhat similar condition in *Canis*. Regarding the deciduous tooth as the first molar, its successor in position would be *pm.4*. Connected with the latter is a "concentric body." Though this tends to support my contention, too much weight must not be attached to it, since a similar structure has been referred to in relation to the posterior teeth in *Cavia*.

Another question opens up: If these "concentric epithelial bodies" are really tooth-vestiges, since they are found in the posterior part of the jaw, either the posterior cheek-teeth must be regarded as premolars, or else these bodies are the vestiges of deciduous molars, and therefore the usually accepted distinction between molars and premolars breaks down. I am inclined to the latter opinion, having always held that the molars belong to the permanent series. If this be a correct interpretation, then in this particular the Rodents retain an extremely primitive condition; and the statements made by Fraas with regard to the tooth-change in *Prolagus* may not be far wrong, and certainly do not merit the unfavourable comments which have been made upon them.

It will have been seen that the cheek-teeth above described arise as a single Primitive cone to be soon followed by the appearance of external and internal cingula. As the tooth elongates, two antero-posterior rows of cusps arise: the primary cone becoming the median-external in position and the largest in size. The anterior and posterior cusps of each row respectively become united forming transverse ridges, the median cones remaining separated by a cleft. The anterior cusp and median cone of the outer row together with the anterior transverse ridge form a crescentic edge, and this gives rise to the anterior moiety of the adult tooth. The median-internal cone disappears. The postero-internal cusp, together with a subsequent backward extension of the end of the tooth, forms the posterior part of the adult tooth,

while the narrow band connecting the anterior and posterior portions represents the posterior transverse ridge. In the younger stages the teeth are decidedly more multitubercular than in the adult. Compare fig. 2 (Pl. 26) with the adult teeth of *Cavia* as shown in fig. 7 B.

In the posterior molars a further small postero-external extension of the tooth arises in the form of a rounded process. It is also present, though to a much less extent, in the anterior cheek-teeth. It is very pronounced and plicated in the posterior molar of *Dolichotis*, and its size forms the principal difference between the molars of this fossil rodent and those of the existing *Caviidæ* (Pl. 26. fig. 7).

It may here be noted that the root of the tooth is frequently seen to be lateral in position, as shown in Pl. 26. fig. 10. This is not usually so marked in other animals, in which the obliquity of the adult teeth is not present to the same extent as in the Rodents.

Within the limits of the Mammalia comparative odontologists have referred to the existence of *four* distinct dentitions—a Pre-milk, a Milk or Deciduous, a Permanent or Successional, and a Post-permanent. The existence of all four at one and the same time has not, so far as I am aware, been shown to be present in the same animal. The Pre-milk dentition is said by Leche and others to be present in the Marsupials, but such an interpretation of the vestigial representatives, such as undoubtedly occur in *Myrmecobius*, *Phascogale*, *Dasyurus*, and others, depends upon the functional teeth of the Marsupials representing the true milk dentition. I have previously [21] expressed my belief that another and more probable explanation is forthcoming, and in this opinion I am supported by Wilson & Hill [24] and by Tomes [23]. I would regard therefore Leche's vestiges as remains of a deciduous dentition. The evidence as to the existence of traces of a Post-permanent dentition in many mammals is, I think, undoubted: they have been described in Man, Seal, Hedgehog, and Dog; and if my interpretation be correct, it is also to be found in Kükenthal's lingual downgrowths of the dental lamina as described by him in *Didelphys* and in the Cetacea.

In the Rodentia there are well-marked evidences of at least two dentitions—the milk and permanent, though the former seems tending to disappear.

The only evidence of the existence of prelacteal vestiges that I have as yet been able to meet with, is to be found in a paper by Adloff [1]. He describes and figures such vestiges in connection with Id. 3 and Id. 2 in *Spermophilus citillus* (head-length 1.5 cm.), and Pd. 2 and Pd. 3 and I. 2, Pd. 2, and Pd. 3 in *Spermophilus leptodactylus* (head-length 2.1 cm.); also in *Sciurus Brookei* in connection with Pd. 2 and Pd. 3, though he does not mention their existence in two other species which he examined, viz., *Sciurus Prevosti* and *S. vulgaris*. He further notes their presence in connection with Pd. 3 and m. 2, m. 2 in *Cavia cobaya* (1.5 cm.). Thus there seems, at first sight, abundant evidence in favour of the existence of the Pre-milk dentition in these animals; but before implicitly accepting these statements, it is necessary to examine them somewhat more critically. Firstly, Adloff's interpretation in connection with the molars of *Cavia* depends entirely upon his belief that the molars belong to the Deciduous or Milk dentition. In this opinion he follows Hoffman, Beauregard, Owen, Leche, and others; on the other hand, Woodward, Lataste, and Magitot believe the molars to belong to the successional series, and in this opinion I concur. Consequently, according to the latter view the vestiges mentioned by Adloff in this position would be regarded as vestiges of the milk predecessors of the molar teeth; and, indeed, I have already described the existence of such a vestige on the labial side of the molar teeth in a foetal pup of about the seventh week [22], as well as the presence of a "concentric body" to the labial side of the molars in the guinea-pig; in both of which cases I have interpreted them as vestiges of a milk dentition, the lingual downgrowth representing a Post-permanent dentition.

With regard to the existence of prelacteal vestiges in the premolar region in the afore-mentioned forms, I may point out that I believe them to be the only examples recorded, Leche's and Woodward's discoveries being confined to the outer incisor region; the very region in which I found well-marked evidences of three dentitions in the dog, but in that instance the three undoubtedly being the Milk, Permanent, and Post-permanent.

With regard to the presence of Pre-milk vestiges in connection with Pd. 2 of *Sciurus Brookei*, there are certain points to be borne in mind.

As I understand Adloff, this tooth Pd. 2 is the anterior of the two premolars so generally present in the *Sciuridæ*. He only

mentions having examined one stage of this species with a head-length of 1.5 cm., and he mentions that neither m. 2 or m. 3 were developed. Now in *Cavia* we have seen that the anterior cheek-tooth present does not develop until after the appearance of the second and third. Similarly, in the dog I have shown (*loc. cit.*) that the small anterior premolars do not appear until some time after the larger posterior ones. According to Flower and Lydekker [5, p. 450] the first upper premolar is "small and deciduous." It therefore seems possible, if not probable, that the tooth which Adloff identifies as Pd. 2 is in reality Pd. 3, that is the posterior deciduous tooth. Now the deciduous tooth in the guinea-pig I have shown to be developed in series with the molars, and in them I have shown the presence of "concentric bodies" which I regard as milk vestiges. In like manner, therefore, the so-called Pre-milk representative in connection with this tooth might be so interpreted. Whether this be the correct explanation or not, I do not consider it possible to identify the teeth from the examination of the condition found in a single specimen.

With regard to Pd. 3 in *Cavia*, I think the interpretation given by Adloff is erroneous, since he appears to have missed the peculiarity of the tooth-change; the "prälakteale Anlage" in this case being identical with the "concentric body."

As to the incisors in *Spermophilus* I am unable to express a definite opinion, not having had an opportunity of examining a specimen; nevertheless I would point out that I am not in accord with Adloff in his identification of dentitions, and the interpretation previously given with regard to the incisors in *Cavia* probably applies equally in the case of *Spermophilus*.

I claim to have shown reason for believing that the existence of pre-milk vestiges in the Rodents is still "non proven"; and I cannot refrain from quoting Woodward, who, though a believer in their existence, and having carried out extensive researches on the dentition of the Rodents, says [27]:—"I do not think it is probable that we should find traces of such a vestigial structure persisting in a specialized group like the Rodentia; the ancestry of which are to be sought according to Cope in the generalized Tillodontia, who in all probability possessed a typical milk-dentition which has become gradually suppressed as their descendants became more and more specialized."

Of the various theories which have been propounded to account for the origin of the complex crown of the Mammalian molars from the Haplodont type, it will be necessary to refer to three only. They are the Tritubercular, the Multitubercular, both of which are well known, and the theory of Cingulum-Cusp development suggested by me in my work on the Canidæ.

*Tritubercular Theory.*—This view, so ably advocated by Cope and Osborn in America, and so widely accepted both in this country and on the continent, is too well known to need any re-statement. One of the important arguments advanced against this theory is that the Paracone, and not the Protocone, is ontogenetically the first to appear. This has been found to be the case in Marsupials [15], Carnivores [22], Ungulates [20], some Insectivores [28], and Primates [16 and 17]. To these may now be added *Cavia*, as representing the Rodents. The other cusps are secondarily added.

The *Multitubercular Theory*, first put forward by Forsyth Major, suggests the primitive condition of the mammalian cheek-teeth to have been multituberculate, and that during the course of evolution a diminution in the number of cusps has taken place. This theory does not appear to me to be applicable to such Orders as those just mentioned with their full complement of teeth, and in which embryology has shown that the teeth develop by the addition of cusps to a single primitive cone. It is evident that this theory presupposes the acceptance of the Concrecence theory as set forth by Dybowski, Gervais, Röse, and more particularly by Kükenthal. Though I am unable to accept these combined views as a whole to account for the origin of the Rodent molars, nevertheless they afford a certain amount of satisfactory evidence; the suggestion which I would offer will be discussed subsequently.

*Theory of Cingulum-Cusp development.*—The uniformity of development of the antero-external cones in both jaws suggests the Paracone and Protoconid as being homologous, and as representing the primitive reptilian cones. The remaining cusps I believe to have been mainly derived from the Cingulum, a structure of great antiquity as shown both embryologically and palæontologically. The details of the subsequent development of the cusps I need not here repeat, as they have been already published [22]. This view is in harmony with the Tritubercular theory up to the

point at which the rotation of the cusps is presumed to have taken place.

In tracing the course of the molar evolution in *Cavia*, it has been found that the tooth begins by the formation of a single cone, which subsequently becomes the antero-external cone of the adult tooth, so far agreeing with what has been noted in other mammalian orders. In the development of teeth from a multituberculate type as usually understood, one would not expect to find the development of a single cone taking place first, as is the case here and elsewhere, but of several. As I have already shown, this single cone of the guinea-pig has both external and internal cingula, the latter being the better marked. Both develop secondary cusps, which disappear in the course of the subsequent development of the tooth. There is thus a tendency to the suppression of cusps after a certain period, the adult tooth being less multituberculate than at an earlier stage, though more so than in its youngest condition. Consequently there is evidence in the later stages of development in favour of the Multitubercular theory.

Though I have not personally met with any direct embryological evidence in support of the Concrescence theory, yet upon general grounds I am disposed to accept it to a certain extent. This theory supposes a fusion to have taken place not only antero-posteriorly of teeth of the same dentition, but also transversely of teeth of different dentitions. The former would account for the diminution in the number of teeth of the same dentition in the transition from the Reptiles to the Mammals; while the latter was suggested in order to explain the existence of the triple longitudinal rows of cusps as seen in the fossil Multituberculata. It is the latter part of this theory that I find myself at present unable to accept.

The progressive shortening of the jaws would naturally tend to a crowding of the teeth, which may be conceived to have become fused antero-posteriorly as a result, and Ameghino [2] has adduced some presumptive evidence in support of this; and I have already referred to the fact that the cheek-teeth in the guinea-pig have similar anterior and posterior portions. It is possible to believe that there may be some close connection in the way of cause and effect between the two processes, though actual evidence is as yet wanting. On the other hand, it is



difficult to imagine how shortening of the jaws could have had any effect in bringing about a fusion of teeth of different dentitions; nor, indeed, can one perceive any other change which would produce such an effect. The suggestion I would offer is, that the three longitudinal rows of cusps are due to the primitive cones with cingulum-cusps developed to their inner and outer sides respectively. It may be objected, that these inner and outer secondary cusps are as pronounced and of equal size as the central primitive cones in the true *Multituberculata*. I do not, however, consider this to be any great difficulty, since the *Multituberculata* must have been extremely specialized animals, as is shown by their dental formulæ; and, moreover, a very similar condition of the cusps is to be seen in the molars of existing frugivorous bears. Each molar tooth of the *Plagiaulicidæ* and *Polymastodontidæ*, in which there are three longitudinal rows of cusps arranged in numerous transverse rows, would consequently represent an antero-posterior fusion of several teeth with their external and internal cusps. In other members of these families, for example *Bolodon*, in which the molars bear only two antero-posterior rows of tubercles, one of the three rows is non-developed.

From a comparison with the teeth of existing mammals, I am inclined to believe that the series in this form which is wanting is that of the external cingulum, it being quite exceptional to find this series well-developed, though it is to be found in some of the *Insectivora* and in *Otocyon* among the *Canidæ*. This conclusion receives some confirmation from a comparison with the teeth of several species of the *Polymastodontinæ*. In a paper by Osborn and Earle [13] describing these, they state that in *P. taoensis*, "although the lower molars typically exhibit but two rows, we occasionally observe a postero-external accessory row upon the first and second molars;" and again, "the comparison with *Meniscoessus* shows an average addition of two cusps to the first molars in both jaws, and an apparent degeneration of the outer row in the second upper molar."

In the course of the development of the molars in the guinea-pig, the three longitudinal rows of tubercles are present as a transitory condition, the external cingulum disappearing giving rise to a tooth with but two antero-posterior rows of tubercles (Pl. 26. fig. 6).

The next point to which I would refer is, the similarity of dentitions found in the *Rodentia* and *Multituberculata*. In both,

the incisors are reduced in number, there is an absence of canines with the presence of a diastema. The number of cheek-teeth in some of the Multituberculata is in excess of that found in most Rodents, while in others it is not in excess of that present in the Lagomorpha. In any case, this is only what might be expected, as it is well known that a progressive reduction in the number of cheek-teeth is, and has been, taking place throughout almost the whole mammalian series.

There still remain other points to be considered in the same connection. Within the limits of the existing Hystricomorpha very different patterns of cheek-teeth are to be found. The crown-surfaces of the so-called anterior permanent premolar of *Hystrix leucura* (Camb. Zool. Mus. 861 D) is shown in fig. 7,

Fig. 7.



Crown of First Upper Permanent Premolar of *Hystrix leucura* before eruption.  
Enlarged. (Camb. Univ. Zool. Mus.)

and of *Cavia cobaya* in Pl. 26. fig. 7 B. The former is decidedly multituberculate, the latter is not. In all the *Hystricidæ* the tooth-change is now known to occur and comparatively late in life, whereas in *Cavia* the deciduous tooth is shed *in utero*. It may, therefore, justly be inferred that the *Hystricidæ* are more primitive in this respect than are the *Caviidæ*. Though this may not altogether justify any conclusions as to the pattern of the molar crowns, nevertheless, taken in conjunction with what has been said above, I think it affords some additional evidence in favour of the conclusion that the multituberculate is the primitive pattern of the Rodent molars.

Lastly, there is a large amount of evidence collected by Forsyth Major in favour of this view, which he was the first to set forth in his paper on the Miocene Squirrels [6].

This opinion, however, was not shared by Cope, and is not by Osborn. Cope derived the Rodentia from the Tillodontia, a suborder of the Bunotheria, from a type closely allied to *Esthonyx*,

*Psittacotherium* being not far from, if not on the direct, line of ancestry [4]. His arguments are based mainly on the presence or absence of the first and third incisors; and the condition found in *Esthonyx*, *Psittacotherium*, *Calamodon*, and *Tillotherium* are referred to as evidence in support. An elaborate theory is then drawn up to show how the Rodent molars may have been produced mechanically from the molars occurring in the above-mentioned fossil forms. This theory, though very ingeniously worked out, is but a theory, and cannot be admitted as evidence. As to the incisors, though I admit that these forms may be so arranged that different stages in their reduction may be made to appear, and the increase in the size of *i.2* to become evident, nevertheless it must not be forgotten that a similar condition is to be met with in the Multituberculata, two incisors only being characteristically present in the genus *Polymastodon*, of which one is very large and "rather slender, sharply grooved, restricted enamel-band, and a deep postero-external groove. The lateral incisor [*i.3*] is a very small conical tooth, compressed antero-posteriorly, with its enamel confined to the anterior surface."

Further, in a note ("Note on the Marsupialia Multituberculata") appended to his paper (*loc. cit.*), Cope stated that the incisors of the *Plagiaulacidæ*, *Chirogidæ*, and *Polymastodontidæ* are similar in structure and functions to those in the Rodentia. Osborn and Earle also say (*loc. cit.*) that the condyle of the lower jaw is "oval, and its long axis is placed obliquely, not antero-posteriorly as in the Rodents." Cope refers to this latter fact as an objection; but it appears to me to be only an objection to his "mechanical theory," and not to the multituberculate theory of descent of the Rodents, for, according to Osborn and Earle (*loc. cit.*), the obliquity is "greater in some specimens than in others," which shows that this is a character which is not stable but undergoing modification.

A further objection may be cited from the joint paper of these authors, as they say that *Polymastodon foliatus* is the most primitive type of the genus, being "distinguished by small size and very few tubercles." With regard to size, I do not think it is necessarily any proof of primitiveness; and as to the number of tubercles, surely the statement partakes somewhat of the nature of "begging the question."

To sum up the matter, it appears to me that the balance of

evidence is distinctly in favour of the multituberculate origin of the Rodents.

This leads to a consideration of the fossil Rodents, for a knowledge of which, especially of the South American forms, we are indebted very largely to the researches of Ameghino, whose work on the fossil mammals of the Argentine [3] forms the source from which other writers have largely drawn. Winge [25], Schlosser [19], and Forsyth Major [6, 7, 8] have also added much that is of value upon the same subject.

Four genera of the *Caviidæ* are reputed to be found in the Tertiary and Pleistocene of Brazil and the Argentine. The members of this family are easily recognized by their high molars composed of two or several triangular prisms which generally form straight lamellæ, and "determinent une arête tranchante sur la face interne des dents à la mâchoire supérieure, et une arête externe à la mâchoire inférieure."

From a consideration of the characters of the post-tympanic and jugular processes and of the masticatory muscles, Winge [25] regards *Cavia*, *Dolichotis*, and *Hydrochærus* as descendants of the American *Capromyina* and places them close to *Dasyprocta* and *Cælogenys*. Ameghino [3], dividing the Hystricomorpha into eight families, places the *Capromyidæ*, the *Eromyidæ*, and the *Caviidæ* in close affinity, and these three families together close to *Octodontidæ*, the points of difference being mainly dental. It will thus be seen that these two authorities agree in their general conclusions. A careful study of the tooth-pattern of the fossil *Caviidæ*, as figured by Ameghino, throws but little light upon the evolution of the molar crowns, there being apparently but little change of pattern from the Eocene, though a comparison of the posterior upper molar of *Dolichotis* from the Pliocene and of *Cavia* shows a reduction in the latter (Pl. 26. fig. 7).

In the table of genealogical descent suggested by Ameghino (*loc. cit.*), he would derive *Cavia* from *Hedimys* through *Paleocavia*, *Eocardia*, and *Phanomys*; there is, however, practically no difference between the molars of these forms such as would throw any light upon the tooth-genesis. If the *Euromyidæ* of the Inferior Eocene be compared with the later Pliocene forms, there is a simplification of the molar crowns though obviously of the same pattern. The more so is this the case on comparison with the *Octodontidæ*.

The same may be said with respect to the *Hystrioidæ*. The diagram (Pl. 26. fig. 8) shows the outline pattern of *Stichomys*, *Spaniomys*, and the recent *Hystrix leucura* (Camb. Zool. Mus.), fig. 7, p. 283. As the teeth are much worn, no information can be obtained as to the original disposition of the tubercles; nevertheless, the outline-pattern, though simpler, is sufficiently similar as to suggest a possible line of descent.

Though it is difficult to obtain any decided results from a comparison of the fossil teeth, owing to the wearing-down to which they have been subjected, still it seems evident that the complexity of the molars, which is undoubtedly more common in the existing forms than in the earlier ones, is due to the external and internal plications of the enamel rather than to the development of new tubercles. These animals, which are undoubtedly Rodents with the characteristic dentition and molar pattern, extend back to the Inferior Eocene. The Tillodontia are not found before the Lower and Middle Eocene, at which period, as we have seen, typical Rodents are present. It is difficult to conceive that the well-developed canines should have disappeared so rapidly and so suddenly together with at least two premolars, and that the incisors, which are only "becoming scalpriform" [26] in the Tillodontia, should have so quickly developed, if we are, with Cope, to regard them as the ancestors of the Rodents. And again, the Rodent molars have already assumed their characteristic pattern, whereas the molars and premolars of *Tillotherium* are "distinctly tritubercular, while those of *Esthonyx* are quite unlike any Rodent molars" [4]. There is also the fact that the humerus in the Tillodontia possesses an entopicondylar foramen, which is not present in any existing Rodent. On the other hand, some of the Multituberculata are considerably older than the earliest known fossil Rodent, extending back into the Jurassic Period. In them the canines and several of the premolars have already disappeared, the incisors reduced in number, one being large and functional, and the pattern of the cheek-teeth in some instances approaching even in some degree to the unworn teeth of the existing *Hystrioidæ*.

*Summary and Conclusions.*

1. That the deciduous tooth in *Cavia* is the first cheek-tooth to develop, the tooth immediately behind it being the next to appear.

2. That the deciduous tooth is replaced by the tooth which develops in front of it, which is its successor in position only, and is not its true morphological successor.

3. The general pattern of the deciduous tooth resembles more closely that of the posterior cheek-teeth than of the anterior tooth. Consequently, the deciduous tooth may possibly represent the first of the so-called molar series.

4. No trace of any representative of a true pre-milk dentition has been discovered.

5. The presence of "concentric epithelial bodies" has been noted in connection with the first and third cheek-teeth. It is suggested that these bodies represent the last traces of milk-teeth. If this be correct, then it would tend to confirm the view, which is not accepted by all, that true molar teeth belong to the permanent series. It would also lead to the conclusion that the usually accepted fundamental difference between premolars and molars did not always hold good, the molars having milk predecessors, of which these bodies are the vestiges.

Moreover, the presence of a similar structure in connection with *pm.4* of *Gymnura* and of *Canis*, tends to confirm the opinion expressed above that the deciduous tooth is the first tooth of the molar series.

6. That in the evolution of the cheek-teeth there is a tendency to the suppression of some cusps and a fusion of others. This conclusion, in conjunction with the evidences of Palæontology, is in favour of the multituberculate origin of the Rodentia.

7. That the first cusp to develop is the antero-external, the so-called Paracone, and not the Protocone as should be the case according to the Tritubercular theory.

8. That a rotation of the whole tooth takes place through an angle of about  $45^{\circ}$ , probably due to the peculiar conformation of the Rodent jaw, so that the anterior part of the adult tooth is represented chiefly by the external cone, the posterior part chiefly by the postero-internal cone.

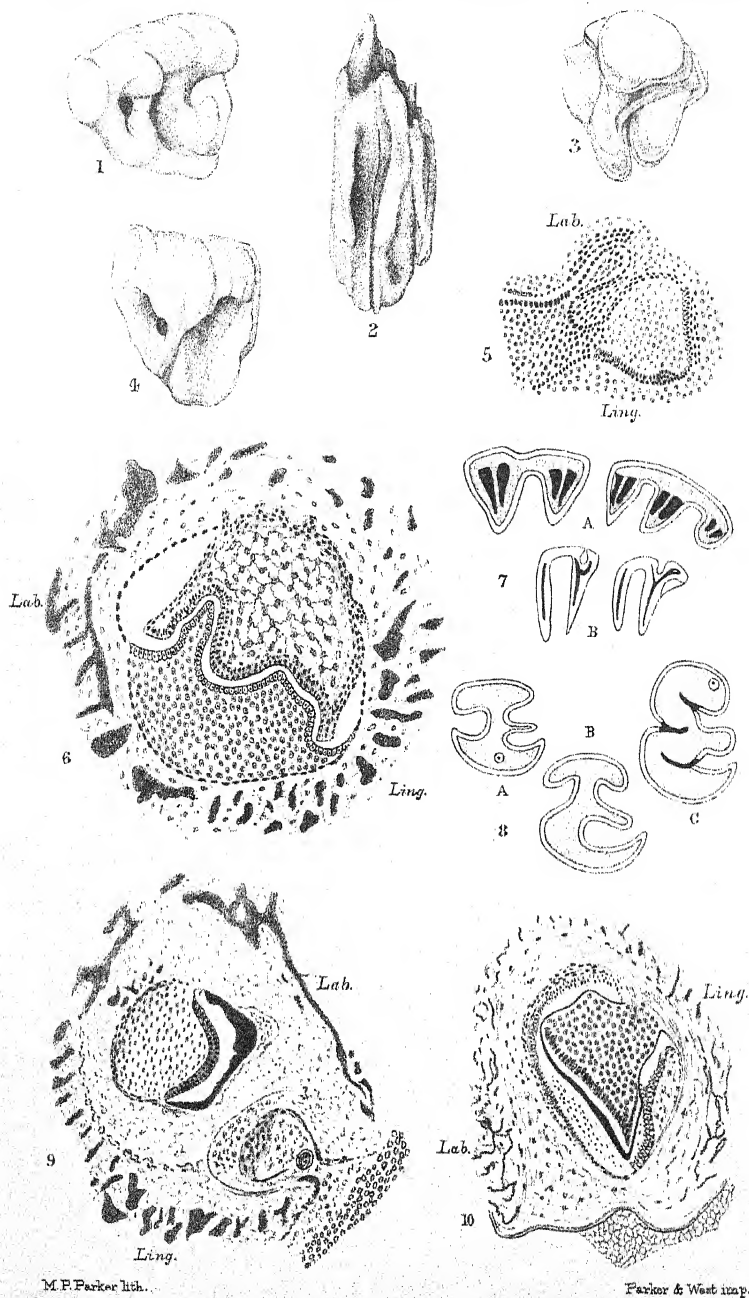
9. The complexity of the Rodent molars is further increased by involutions of the enamel, the first to appear being at the lingual side of the tooth, and followed by another on the external surface in the teeth of the Rat.

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Parker & West map.

TOOTH GENESIS IN THE CAVIIDÆ.

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## EXPLANATION OF PLATE 26.

- Fig. 1. Drawing of wax model of Left Upper Deciduous Molar. Postero-internal view. Stage II.
2. Drawing of wax model showing crown-surface of Left Upper Successional Molar. Stage III.
  3. Drawing of wax model of Left Third Upper Cheek-tooth. Posterior view. Stage II.

- Fig. 4. Drawing of wax model of Left Upper Deciduous Molar. Postero-internal view. Stage III.
5. Section through Left Upper Permanent Incisor, showing Labial down-growth of Dental Lamina. Stage I.
  6. Section through Successional Molar. Stage III.
  7. Crown-surfaces of the last two Upper Molars of
    - A. *Dolichotis platycephalica* (after Ameghino).
    - B. *Cavia cobaya*. Both much enlarged.
  8. Crown-surface of Upper Molar of
    - A. *Stichomys constans*. Inferior Eocene (after Ameghino).
    - B. *Spaniomys riparius*. " " "
    - C. *Hystrix leucura*. Recent. (Camb. Univ. Zool. Mus.)
  9. Section through Deciduous and Successional Molars of *Cavia*, showing "concentric epithelial body" in connection with the former. Stage II.
  10. Section through a Posterior Molar, showing lateral position of the root.

Contributions to the Malacostracan Fauna of the Mediterranean.  
By ALFRED O. WALKER, F.L.S.

[Read 7th March, 1901.]

(PLATE 27.)

THE following results of a short stay at Cannes and Hyères are interesting as showing what may be done in a few hours' dredging from an open boat, in depths never exceeding 35 fath., and with the simplest apparatus. This consisted of a tow-net of tiffany (such as is used by gardeners for shading greenhouses), strengthened at the bag end by cheese-cloth sewn over it for about 2 ft. in length, and attached to a cane rim 6 or 8 in. in diameter. The cane is important, as the net should be as light as possible so as not to scoop up the sand, in which case it fills up immediately. This net is attached to a stone heavy enough to remain on the bottom while the boat is rowed rather quickly; the distance of the net from the stone varying from 3 feet on coarse sand to 6 feet or more on mud. The stone stirs up the Crustacea, which find their way into the net with a certain amount of sand, though far less than in the case of a dredge (however light), or metal-rimmed tow-net. This, with two small buckets such as are used by children at the sea-side, a small muslin-bag attached to a brass rim with a brass grating on the top, two or three glass jars (*e. g.* French-plum jars), 75 fathoms of line, and plenty of tubes large and small, constitute the

entire apparatus required. A basket 18 inches by 12 inches, by 10 inches deep, contained the whole. An open boat rowed by one man was used. I dredged five times at Cannes and once at Hyères, for about 2 hours each time.

The total numbers of species in each division of the Malacostraca were as follows:—

Podophthalmata .....	10
Schizopoda, including 1 new species .. ..	8
Cumacea.....	9
Isopoda exclusive of Chelifera, 2 new species .....	9
Amphipoda, including 2 new species and 2 not previously recorded in the Mediterranean ...	41
Pantopoda.....	1
	<hr/>
	78

I need hardly say that other classes of marine animals were also brought up, especially Nudibranchs, some of which were most beautifully coloured. One of these was ultramarine-blue with 2 or 3 longitudinal white stripes; another had the inside of the wavy mantle dark green, while the rest of the animal was white with scarlet spots.

The following were the stations:—

#### Cannes.

1. Feb. 4. A short distance S. & S.W. of the breakwater, 10 fath., sand.
2. Feb. 8. Cap d'Antibes, shore among stones and *Posidonia*-fragments.
3. Feb. 10. West end of Ile Ste. Marguerite, 15-20 fath., sand and broken Corallines; decomposed *Posidonia*.
4. Feb. 16. Half a mile to  $1\frac{1}{2}$  mile S.E. of Croisette Point, 14 fath. (sand and *Posidonia*, "a") to 25 fath. (mud, "b").
5. Feb. 18. West end of Ile Ste. Marguerite, farther out than on the 10th, 25-35 fath. Coarse sand and broken shells.
6. Feb. 21. Between the breakwater and Croisette Point, 15 fath., sand and *Posidonia*.

#### Hyères.

- 1 H. Mar. 1 & 3. Shore at Pomponia, stones and *Posidonia*-fragments.

2 H. Mar. 6. Between Pomponia and Carquerannes, 2-4 fath., sand and *Posidonia*.

The shore is for the most part sandy and covered with the spiny débris of *Posidonia Caulini*, Kön. (= *Zostera oceanica*, All.). On the rocks at Cap d'Antibes, and at Pomponia, Hyères, I was unable to find any Hydrozoa or Polyzoa, and Algæ were extremely scarce.

### BRACHYURA.

*PACHYGRAPSUS MARMORATUS* (*Fabr.*).

Under stones. St. 2, 1 H.

In its habits this species resembles our familiar shore-crab, *Carcinus mænas*, but runs more swiftly when disturbed.

*ACHÆUS CRANCHII*, *Leach*.

St. 5. One young.

### ANOMURA.

*EUPAGURUS ANGULATUS* (*Risso*).

St. 5. One specimen.

*GALATHEA* sp.

St. 5. One: too young for identification.

### MACRURA.

*CRANGON SCULPTUS*, *Bell*.

St. 3, 5.

One specimen was infested with a parasite under the thorax.

*ATHENAS NITESCENS*, *Leach*.

St. 5. Three very young.

*HIPPOLYTE VIRIDIS* (*Otto*).

St. 1, 2 H.

Several, including a few with one tooth at the base of the rostrum on the upper side. All were bright green.

*HIPPOLYTE GRACILIS* (*Heller*).

St. 2 H. Four or five.

*HIPPOLYTE VARIANS*, *Leach*.

St. 6. A few young.

*PALEMON SQUILLA* (*Fabr.*).

St. 5. One young.

## SCHIZOPODA.

*SIRIELLA CLAUSII*, Sars.

Cannes and Hyères, 2-30 fath.

This was the most abundant crustacean I met with: most of the specimens were immature.

*ANCHIALUS AGILIS*, Sars.

St. 3, 5, 6. Several.

*ERYTHROPS ELEGANS*, Sars.

St. 5. Three young.

*PSEUDOMMA*, sp.

St. 5. A head only.

*MYSIDOPSIS GIBBOSA*, Sars.

St. 4 *a*, 4 *b*. Three or four.

Genus *MYSIDOPSIS* ?

*MYSIDOPSIS* (?) *SERRATICAUDA*, n. sp. (Pl. 27. figs. 1-6.)

St. 3. One adult female. Length 5 mm.

General form rather slender. Carapace smooth, the frontal margin somewhat produced, forming an obtuse angle.

Eyes subglobose, the greater part occupied by the pigment.

Upper antennæ much as in *M. didelphys*, Norman.

Lower antennæ also of the usual form; antennal scale narrow lanceolate, more than twice as long as the peduncle, and eight times as long as wide at the base; terminal joint very small.

Legs slender, about as long as the antennal scale; tarsus, including the terminal tuft of setæ and the nail, about as long as the preceding joint; its first joint about twice as long as the 2nd and rather longer than the 3rd.

Telson about as long as the inner uropod, tapering gradually, with 9 *teeth* (not spines), increasing in size towards the extremity, on each margin, and two strong *spines* on each side of the emarginate apex.

Inner uropod very little shorter and narrower than the outer; a strong spine at the base.

Mandibular palp apparently absent.

Length including uropods 5 mm.

Easily distinguishable by the serrate or dentate margins of the telson. *M. angusta*, Sars, which has the basal part of this

member dentate, is its nearest ally. The absence of a palp to the mandibles will probably require the formation of a new genus when the male is taken.

LEPTOMYSIS APIOPS, *Sars*.

St. 5. Three or four.

DIAMYSIS BAHIRENSIS (*Sars*).

St. 1, 6. Two or three young.

### CUMACEA.

CUMA SCORPIOIDES (*Mont.*).

St. 2 H. Two males, two females, all immature. Length 4 mm.

CUMA PULCHELLA, *Sars*.

St. 1. One young female. Length 2 mm.

IPHINOË SERRATA, *Norman*.

St. 3, 5, 6.

The commonest Cumacean at Cannes: all the specimens were immature. This is now considered by G. O. Sars to be distinct from *I. trispinosa* (Goodsir), of which he formerly believed it to be a mere variety (Crust. of Norway, vol. iii. p. 14).

CYCLASPOIDES CORNIGERA (*Sars*).

St. 3. Four specimens.

DIASTYLIS RUGOSA, *Sars*.

St. 3, 5, 6. Several.

DIASTYLOIDES BIPPLICATA, *Sars*.

St. 3, 5, 6. Five specimens. Length 3.25 mm.

None of the specimens had more than 4 marginal spines on the telson instead of 12: this is probably a condition of immaturity.

PSEUDOCUMA CERCARIA (*v. Beneden*).

St. 6, 2 H. Two specimens.

CUMELLA PYGMÆA, *Sars*.

St. 6. One female. St. 2 H. One male.

NANNASTACUS LONGIROSTRIS, *Sars*.

St. 2 H. One female.

## ISOPODA.

## CHELIFERA.

Several species of these were taken and have been placed in the able hands of Mons. A. Dollfus, who has kindly undertaken to name them.

## FLABELLIFERA.

## Fam. ANTHURIDÆ.

Genus *HYSSURA*, *Norman & Stebbing*.

*HYSSURA SPINICAUDA*, n. sp. (Pl. 27. figs. 7-11.)

St. 2 H. Two specimens.

Head about the same length and width as the first segment; frontal margin slightly produced in the middle. Eyes wanting.

Mesosome: the first and last segments the shortest, next the 3rd; remaining segments longer, subequal.

Metasome exclusive of the telson rather wider than the mesosome; not as long as its last two segments; segments well defined, 6 in number, including the caudal segment.

Antennæ: the upper not reaching the end of the peduncle of the lower; joints of the peduncle swollen; flagellum 3-jointed, as long as the last joint of the peduncle. Lower antennæ not bent outwards, peduncle 5-jointed, the last joint the longest; flagellum 7-jointed, rather longer than the last joint of the peduncle.

Legs: the first 3 pairs subchelate, the 2nd pair the broadest, then the 1st, the 3rd much smaller; the propodos oval, the 1st joint longer and wider than the 2nd, about as long as the 5th (propodos), the 3rd joint expanded anteriorly to support the base of the 5th, the 4th is articulated to the hinder angle of the 3rd and forms an elongate triangle of which the inner margin lies along the posterior margin of the propodos. The 1st pair has the propodos relatively narrower than the 2nd. The remaining (ambulatory) legs are short and of the usual form: all are attached to the front of their respective segments, except the 7th which are attached to the hind part.

Uropoda narrow oblong, the rami subequal; the outer and uppermost rather the narrower and armed with three or four long and strong spines on the inner margin.



Telson elongate triangular, about as long as the uropods, with 6 or 7 short spines on each margin, and a few divergent setæ on the apex which is rounded.

Length 3 mm.

The genus *Hyssura* has hitherto been known only from a single specimen of *H. producta* described by Norman & Stebbing in their "Isopoda of the 'Lightning,' &c." (Trans. Zool. Soc. vol. xii. Part iv. 1886, p. 128, pl. xxv. fig. v.), and dredged by H.M.S. 'Valorous' in 1875 in the North Atlantic in lat. 56° N., long. 37 W., in 1450 fath. It is difficult to imagine a greater contrast in the conditions of life than exists between the bright light and high temperature of the Mediterranean, where I could plainly see the bottom with its alternate patches of weed and sand, and the cold and darkness of the Atlantic at such a depth! Yet the apparent differences of structure are very slight—only the relative proportions of the first 3 pairs of legs, and the spines on the uropods and telson, which do not exist in the Atlantic species. There is no vestige of eyes in either species.

PARANTHURA NIGRO-PUNCTATA (*Lucas*).

St. 1. One young.

Fam. CIROLANIDÆ.

EURYDICE ACHATA (*Slabber*) = *E. pulchra*, *Leach*.

St. 2 h. Two young.

Fam. SPHEROMIDÆ.

SPHEROMA SERRATUM (*Fabr.*).

St. 2. Several.

DYNAMENE RUBRA (*Mont.*).

St. 1 h. One young.

CAMPECOPEA CORALLINA ?, *Risso*.

St. 1 h. One young.

ASELLOTA.

Fam. JANIRIDÆ.

JEROPSIS DOLLFUSI, *Norman*.

St. 5. One. Length 3.5 mm.

The only previous record is from the island of Capri, Bay of Naples (Ann. & Mag. Nat. Hist. ser. 7, vol. iv. p. 290, pl. v.).

## Fam. MUNNIDÆ.

## PLEUROCOPE, n. gen.

(Greek *pleuron*, side, *kōpē*, handle, from the form of the lateral processes.)

General form of the body like *Pleurogonium*: sides of the segments and head produced and terminated (except the 4th and 7th) by a conspicuous process.

Head large, deeply sunk in the 1st segment, with a lobe at the base of the upper antennæ and a process behind the lower antennæ.

Upper antennæ shorter and slighter than the lower.

Mandibles not seen.

Maxillæ as in *Pleurogonium*.

Maxillipedes with the inner plate very broad; palp slender; epignath oval, rounded.

Legs scarcely increasing in length posteriorly.

Caudal segment long and tapering.

Uropoda conspicuous, with two subequal rami; they are placed near the base of the caudal segment.

This genus differs from *Pleurogonium*, its nearest ally, in the large size and peculiar appendages of the head, the different relative proportion and structure of the antennæ, in the form of the caudal segment, and in the position and size of the uropods, which are unusually large for this family.

## PLEUROCOPE DASYURA, n. sp. (Pl. 27. figs. 12-18.)

St. 1. One female.

Body minutely granulate; lateral processes of the body and head linear and terminated by a long spine-like seta directed backwards and two smaller setæ. The 4th segment has a single curved seta directed forwards in place of the process. The caudal segment is as long as the five preceding, tapering rapidly to the middle and thence gradually to a point. The distal half is clothed with setæ directed backwards and increasing in length distally; on each side of the apex there is a curved seta directed outwards and slightly forwards. The operculum in the female is pyriform, with two long setæ at the apex.

Antennæ: upper shorter than the width of the head, and barely reaching to the end of the peduncle of the upper; the 3-jointed peduncle rises from the base of a narrow lobe directed

forwards and terminated by a row of divergent setæ; the 1st joint about half the length of either of the others. The 6-jointed flagellum about equals the peduncle. The lower antennæ are much stronger than the upper; the peduncle 2-jointed; the flagellum 4-jointed, hardly as long as the peduncle.

First pair of legs but little shorter than the others, the 1st and 2nd joints subequal and narrow, shorter than the 5th (propodos); the 3rd and 4th short, the latter produced and terminated by 4 or 5 spines; the 5th long-oval; the dactylus long, with a secondary tooth near the base.

Ambulatory legs as in *Pleurogonium*.

Uropoda placed near the base of the caudal segment, the peduncle about half the length of the subequal rami, with two long divergent setæ at the distal end; rami about as long as the lateral processes, and similarly armed with retroflexed spines or setæ.

Length 1.2 mm.

I am much indebted to Mr. Andrew Scott for dissecting and figuring this minute and curious Munnid. I have no hesitation in saying that without his kind assistance I should have been unable to describe it.

## ONISCOIDA.

### Fam. LIGIDÆ.

*LIGIA ITALICA*, *Fabr.*

St. 1 H.

Common at Pomponia, where it may be seen running rapidly over the stones on the shore in full sunshine. The larger individuals had a whitish patch on the back.

## AMPHIPODA.

### HYPERIIDÆ.

*PHROSINA SEMI-LUNATA*, *Risso.*

St. 4b. One young. Length 3 mm.

### GAMMARIDÆ.

#### Fam. ORCHESTIIDÆ.

*HYALE PONTICA*, *Rathke.*

St. 2 H. A few young.

ALLORCHESTES AQUILINA (*Costa*). (Pl. 27. fig. 19.)

= *Amphithoë aquilina*, *Costa*. *Hyale aquilina*, *Della Valle*.

St. 1 H. Several, male and female.

The carpus of the 2nd gnathopods of the male is produced into a slender spur. This is not shown in *Della Valle*'s figure, and brings the species into the genus *Allorchestes* as defined by *Stebbing* (*Trans. Linn. Soc. 2nd ser. vol. vii. pp. 397/8*).

ALLORCHESTES PLUMICORNIS (*Heller*). (Pl. 27. figs. 20, 21.)

*Nicea plumicornis*, *Heller*.

St. 1. Several; males, females, and young.

I am glad to be able to confirm Mr. *Stebbing*'s opinion (*l. c.* pp. 412/3), that *Heller* mistook males for females. The second gnathopod in the female differs entirely from *Heller*'s figure. The lower antennæ, however, are hairy in both sexes though less so in the female. This is one of several species wrongly united with *Hyale Prevostii*, *M.-Edw.*, by *Della Valle*.

#### FAM. LYSIANASSIDÆ.

ORCHOMENE HUMILIS (*Costa*) = *O. Batei*, *Sars*.

St. 3. One young.

#### FAM. PONTOPOREIIDÆ.

UROTHOË sp.

St. 2 H. One female, too young for identification. Length 2 mm.

#### FAM. PHOXOCEPHALIDÆ.

Genus METAPHOXUS, *Bonnier*,

*Camp. du Caudan*, *Ann. l'Université de Lyon*, 1896, p. 630.

This genus was founded by *Bonnier* for *Metaphoxus typicus*, a species which, as he says, is extremely near to *Phoxocephalus pectinatus*. The genus appears to be a natural one, and should I think include *P. Fultoni*, *Scott*.

M. FULTONI (*T. Scott*) = *Phoxocephalus chelatus*, *Della Valle*.

St. 5, 2 H. Several.

M. PECTINATUS (*A. O. Walker*). (Pl. 27. fig. 22.)

1896. *Phoxocephalus simplex*, *Calman*, *Trans. Roy. Irish Acad. vol. xxx.*

1900. *P. simplex*, *Norman*, *Ann. & Mag. Nat. Hist. ser. 7, vol. v. p. 335.*

1900. *M. pectinatus*, Cherreux, Résult. des Camp. scientifiques &c., Amphipodes de l'*Hirondelle*.

Not *Phoxus simplex*, Bate or Bate & Westwood.

I regret that I cannot agree with so eminent an authority as Dr. A. M. Norman in uniting this species with *Phoxus simplex* of Sp. Bate. In order to show the identity of the two species, Dr. Norman has to reject Bate's type specimen in the British Museum and to adopt the descriptions (insufficient at best) in the Brit. Mus. Catalogue and the Brit. Sessile-eyed Crustacea—which agree neither with each other (as he admits) nor with *M. pectinatus*—and the figures of a notoriously inaccurate draughtsman!\* Surely this is not the kind of evidence on which a published species should be annulled! This is not the first time that *P. simplex* has been wrongly appropriated, Boeck having assigned *Leptophoxus falcatus*, Sars, to it in 1872.

I have pointed out some of the differences between the two species in Ann. & Mag. Nat. Hist. ser. 6, vol. xviii. p. 157, and I now give a figure of the head of Bate's type specimen of *Phoxus simplex* in the British Museum (Pl. 27. fig. 23).

HARPINIA NEGLECTA, Sars.

St. 4 b. A few.

HARPINIA CRENULATA, Boeck.

St. 5. Several, very small.

#### Fam. AMPELISCIDÆ.

AMPELISCA DIADEMA (Costa).

St. 4 b. Five young.

Della Valle refers *A. tenuicornis*, Liljeb., to this species, to which it is certainly nearly allied. My specimens are too young to determine the question.

AMPHILOCHUS NEAPOLITANUS, Della Valle.

St. 1 h. Two young. Length 1.5 mm.

Dr. A. M. Norman refers *A. melanops*, Walker, to this species, and hints that *A. brunneus*, D. V., might also be joined to it. I concur in this, especially as regards the last named, as I hold that *A. melanops* has a closer affinity to *A. brunneus* than to *A. neapolitanus*. Of this last Della Valle says not only that the

\* Conf. Stebbing, 'Fauna Hawaiianis,' p. 530.

carpal process reaches to the extremity of the posterior margin of the hand, as quoted by Norman, but that it goes beyond it ("raggiunge ed oltrepassa")\*. This I have never seen in any British specimen, but it is the case with one of the Hyères specimens, while in the other it just reaches the palmar angle, as is the case with many British examples. On the other hand, I have a specimen from Jersey in which the process only reaches to the middle of the posterior margin; while in another, taken at the same time and place, it covers about two-thirds of it. Other specimens (from N. Wales) have the process longer in various degrees; and it may therefore be taken to be an unreliable character for purposes of classification.

Besides the difference in the carpal process, Della Valle says that the hand of the 2nd gnathopods in *A. neapolitanus* is much wider ("molto piu larga") than that of the 1st, while in *A. brunneus* they are almost alike except that the 2nd is larger. The figures correspond with the description. I find, however, that this, as well as the extent to which the palmar angle is rounded off, is another variable feature.

When *A. melanops* was published as a species, *i. e.* before the discovery of the intermediate forms, the three species were easily definable as follows:—

Carpal process of 2nd gnathopods reaching to	(1) the middle of the post. margin of the propodos.	<i>A. brunneus</i> , Della Valle.
	(2) beyond the middle but not beyond its extremity.	<i>A. melanops</i> , Walker.
	(3) beyond the extremity; hand very wide.	<i>A. neapolitanus</i> , D. V.

Finally, it is a question whether all three species should not be united to *A. Marionis*, Stebbing ('Challenger' Amphipoda), notwithstanding the immense distance between their respective habitats.

*GITANA SARSII*, Boeck.

St. 4 a, 6. Five specimens.

Fam. CRESSIDÆ, Stebbing.

*CRESSA DUBIA* (Bate).

St. 3. One specimen. Length 1.5 mm.

\* It is also more slender and pointed than in *A. brunneus* and *A. melanops*, as correctly figured by Della Valle.

Not previously recorded in the Mediterranean. The quantity of pigment in this species is remarkable; the above specimen coloured a mixture of spirit, glycerine, and water in the tube  $\frac{3}{4}$  in. deep by  $\frac{1}{4}$  in. diameter, deep yellow.

Fam. LEUCOTHOIDÆ.

Genus LEUCOTHOE.

*L. SPINICARPA* (*Abildgaard*).

St. 4a. Three young.

*L. EURYONYX*\*, n. sp. (Pl. 27. figs. 24-26.)

St. 6. Three (?) young. Length 1.75 mm.

Body moderately compressed; first four coxal plates not quite as deep as the segments, the 1st expanded downwards, 2nd, 3rd, and 4th quadrate with rounded angles. Last epimeral plates of metasome notched above the posterior angle.

Head: upper margin exceeding that of the 1st segment of the mesosome by the length of the rostrum which is about one-third of the total length of the head; eyes small, round.

Upper antennæ as long as the head and first three segments; first joint of the peduncle about one-fourth longer than the second, which is about twice as long as the third; flagellum 3-jointed, about as long as the second joint of the peduncle.

Lower antennæ reaching a little beyond the end of the peduncle of the upper; second joint of the peduncle about one-third longer than the last, which is rather longer than the 3-jointed flagellum. No setæ on either pair of antennæ.

First gnathopods: carpal process slightly curved and gradually tapering to a point, not quite reaching the end of the propodos, the margins of which are parallel; dactylus about one-third the length of the propodos, slender and recurved near the point.

Second gnathopods: the carpal process, which is hollowed to receive the lower margin of the hand, reaches a little beyond the palmar angle of the propodos; it is fringed beneath with rows of setæ and is toothed at the distal end. The propodos has the anterior margin rather concave towards the apex, and produced considerably beyond the insertion of the dactylus, which is unusually short and wide; the minutely denticulate palm is

\* "Wide-nailed," in allusion to the short, broad dactylus of the 2nd gnathopod.

about half the length of the posterior margin with which it forms an angle of about 45 degrees.

Peræopods: the first three pairs have the 1st joint very long and narrow; in the last two pairs it is about half as long again as wide; dactyli strong, about half as long as the preceding joint.

Uropods: the shorter ramus of the second pair reaches the distal end of the peduncle of the 3rd pair, which project a little beyond the first pair.

Telson of the usual form, reaching nearly to the end of the 3rd uropod.

This little species differs from all others known to me in the projecting anterior angle of the propodos, its short and well-defined palm, and short, wide dactylus, from which it takes its specific name.

Fam. OEDICERIDÆ.

MONOCULODES GRISEUS (*Della Valle*).

*Oedicerus griseus*, Della Valle.

St. 5, 6. A female with ova and a few young. Length of female 3 mm.

PERIOCULODES LONGIMANUS (*Bate*).

St. 5. Many. St. 2 H. One.

Some specimens had the gnathopods shorter and wider than the typical form.

SYNCHELIDIUM HAPLOCHELES (*Grube*).

St. 5, 2 H. A few.

HALIMEDON RECTIROSTRIS, *Della Valle*.

St. 5, 6. Five. Length 3-4 mm.

The rostrum in these specimens is not so long as figured by Della Valle, reaching only just beyond the end of the 1st joint of the upper antennæ.

Fam. IPHIMEDIDÆ.

IPHIMEDIA MINUTA, *Sars*.

St. 3. Two. Length 2.5 mm.

Fam. CALLIOPIDÆ.

APHERUSA BISPINOSA (*Bate*).

*Pherusa bispinosa*, Nebeski.

St. 1, 2 H. Common.



## Fam. ATYLIDÆ.

PARATYLUS GUTTATUS (*Costa*). (Pl. 27. figs. 27, 28.)

*Nototropis guttatus*, *Costa*. *Nototropis spinulicauda*, *Costa*.

*Atylus Costæ*, *Heller*.

St. 2 H. Three young, the largest 3 mm.

Very like *P. vedlomensis* (*Bate*), from which it differs in the relative proportions of the joints of the upper antennæ and in the absence of the downward prolongation of the 1st joint of the 5th pair of legs (3rd peræopods). *Della Valle* is certainly wrong in referring this species to *Dexamine spinosa* (*Mont.*), as the mandible has a small 3-jointed palp.

DEXAMINE? SPINOSA (*Mont.*).

St. 2 H. Three or four young.

The specimens resemble *D. Thea*, *Boeck*, rather than *D. spinosa*, but are too young for certain identification. *D. Thea* has not yet been recorded in the Mediterranean.

TRITETA GIBBOSA (*Bate*).

*Dexamine dolichonyx*, *Nebeski*, ♂.

St. 2 H. One. Length 2 mm.

GUERNEA COALITA (*Norman*).

St. 5, 2 H. Two young. Length 1.5 mm.

Fam. MELPHIDIPPIDÆ, *Stebbing*.

MELPHIDIPPA, n. sp. (Pl. 27. figs. 29, 30.)

St. 5. Four specimens. Length 3 mm.

This is an intermediate form between *Melphidippa*, *Boeck*, 1870, and *Melphidippella*, *G. O. Sars*, 1895. It has the 1st and 2nd gnathopods alike in form, with the carpus expanded as in the former genus, while the enormous eyes and small terminal joint of the mandibular palp belong to the latter. As usual in these genera, the legs &c. are too imperfect to enable one to describe the species properly. I am not aware that either genus has been recorded from the Mediterranean before.

## Fam. GAMMARIDÆ.

GAMMARUS MARINUS, *Leach*.

St. 2. Several.

*MÆRA SCISSIMANA* (Costa).*Gammarus scissimanus*, Costa. *Mæra truncatipes*, Della Valle.

St. 2 H. Two males, one female. Length 5 mm.

The characteristic notch in the palm of the 2nd gnathopods is wanting in a young male. This may be the form described by Heller as *M. integrimana*, which appears to be the opinion of Della Valle, as he treats the two species as synonymous. A female taken with the males has the lower antennæ shorter and the limbs stouter.

*MELITA PALMATA* (Mont.).

St. 1 H. Three or four.

## Fam. LILJEBORGIDÆ, Stebbing.

*LILJEBORGIA PALLIDA*, Bate.

St. 3. Three. Length 3 mm.

*GAMMARELLA BREVICAUDATA*, M.-Edw.

St. 2 H. One young.

*MEGALUROPUS AGILIS*, Norman.

St. 6. One young.

## Fam. AORIDÆ, Stebbing.

*MICRODEUTOPUS ALGICOLA*, Della Valle.

St. 6. One male. Length 3.5 mm.

*AORA GRACILIS*, Bate.

St. 2 H. One male. Length 4 mm.

*AUTONOË LONGIPES*, Liljeb.

St. 3. Several young. St. 1 H. One female with ova, length 5 mm.

## Fam. PHOTIDÆ.

*LEPTOCHEIRUS GUTTATUS* (Grube).

St. 2 H. Four specimens.

For some interesting observations on this genus see Chevreux, Camp. Scient., fasc. xvi. Amphipodes de l'*Hirondelle*, pp. 90-92.

*MEGAMPHOPUS CORNUTUS*, Norman.

St. 4 b. One female. Length 2.5 mm.

Not previously recorded from the Mediterranean.

## Fam. ATYLLIDÆ.

PARATYLLUS GUTTATUS (*Costa*). (Pl. 27. figs. 27, 28.)

*Nototropis guttatus*, *Costa*. *Nototropis spinulicauda*, *Costa*.

*Atylus Costæ*, *Heller*.

St. 2 H. Three young, the largest 3 mm.

Very like *P. vedlomensis* (*Bate*), from which it differs in the relative proportions of the joints of the upper antennæ and in the absence of the downward prolongation of the 1st joint of the 5th pair of legs (3rd peræopods). *Della Valle* is certainly wrong in referring this species to *Dexamine spinosa* (*Mont.*), as the mandible has a small 3-jointed palp.

DEXAMINE? SPINOSA (*Mont.*).

St. 2 H. Three or four young.

The specimens resemble *D. Thea*, *Boeck*, rather than *D. spinosa*, but are too young for certain identification. *D. Thea* has not yet been recorded in the Mediterranean.

TRITETA GIBBOSA (*Bate*).

*Dexamine dolichonyx*, *Nebeski*, ♂.

St. 2 H. One. Length 2 mm.

GUERNEA COALITA (*Norman*).

St. 5, 2 H. Two young. Length 1.5 mm.

Fam. MELPHIDIPPIDÆ, *Stebbing*.

MELPHIDIPPA, n. sp. (Pl. 27. figs. 29, 30.)

St. 5. Four specimens. Length 3 mm.

This is an intermediate form between *Melphidippa*, *Boeck*, 1870, and *Melphidippella*, *G. O. Sars*, 1895. It has the 1st and 2nd gnathopods alike in form, with the carpus expanded as in the former genus, while the enormous eyes and small terminal joint of the mandibular palp belong to the latter. As usual in these genera, the legs &c. are too imperfect to enable one to describe the species properly. I am not aware that either genus has been recorded from the Mediterranean before.

## Fam. GAMMARIDÆ.

GAMMARUS MARINUS, *Leach*.

St. 2. Several.

*MERA SCISSIMANA* (*Costa*).*Gammarus scissimanus*, *Costa*. *Mera truncatipes*, *Della Valle*.

St. 2 H. Two males, one female. Length 5 mm.

The characteristic notch in the palm of the 2nd gnathopods is wanting in a young male. This may be the form described by Heller as *M. integrimana*, which appears to be the opinion of Della Valle, as he treats the two species as synonymous. A female taken with the males has the lower antennæ shorter and the limbs stouter.

*MELITA PALMATA* (*Mont.*).

St. 1 H. Three or four.

Fam. LILJEBORGIDÆ, *Stebbing*.*LILJEBORGIA PALLIDA*, *Bate*.

St. 3. Three. Length 3 mm.

*GAMMARELLA BREVICAUDATA*, *M.-Edw.*

St. 2 H. One young.

*MEGALUROPUS AGILIS*, *Norman*.

St. 6. One young.

Fam. AORIDÆ, *Stebbing*.*MICRODEUTOPUS ALGICOLA*, *Della Valle*.

St. 6. One male. Length 3.5 mm.

*AORA GRACILIS*, *Bate*.

St. 2 H. One male. Length 4 mm.

*AUTONOË LONGIPES*, *Liljeb.*

St. 3. Several young. St. 1 H. One female with ova, length 5 mm.

## Fam. PHOTIDÆ.

*LEPTOCHEIRUS GUTTATUS* (*Grube*).

St. 2 H. Four specimens.

For some interesting observations on this genus see Chevreux, Camp. Scient., fasc. xvi. Amphipodes de l'*Hirondelle*, pp. 90-92.

*MEGAMPHOPUS CORNUTUS*, *Norman*.

St. 4 b. One female. Length 2.5 mm.

Not previously recorded from the Mediterranean.

PHOTIS LONGICAUDATA (*Bate*).

*Photis Reinhardi*, Della Valle.

St. 2 H. One female. Length 2.25 mm.

I agree with M. Chevreux (*l. c.* p. 93) that Della Valle's figures &c. refer to this species.

Fam. AMPHITHOIDE, *Stebbing*.

PLEONEXES GAMMAROIDES, *Bate*.

St. 2 H. One young. Length 2 mm.

#### CAPRELLIDEA.

Fam. CAPRELLIDE.

PHYSISICA MARINA, *Slabber*.

St. 6. Three or four.

CAPRELLA ACANTHIFERA, *Leach*.

St. 2 H. One young.

#### PANTOPODA.

AMMOTHEA ECHINATA (*Hodge*).

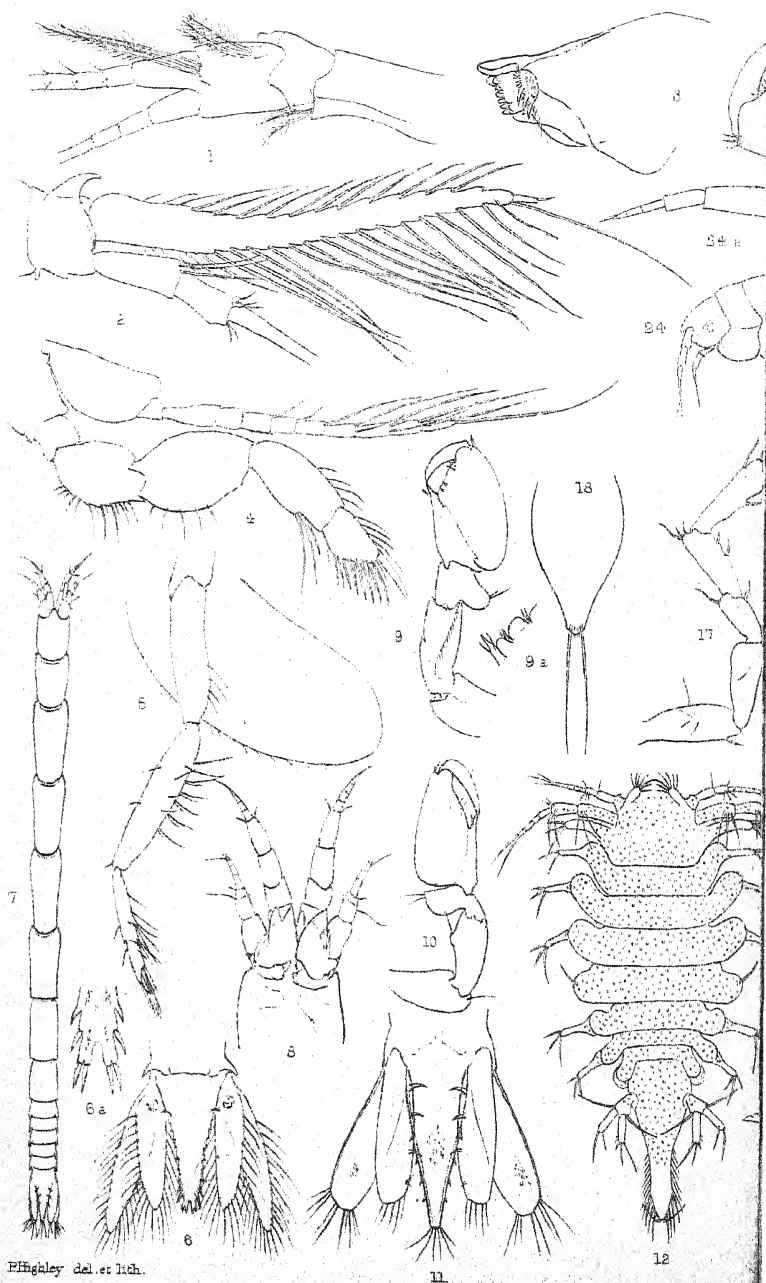
St. 1. One male.

#### COPEPODA.

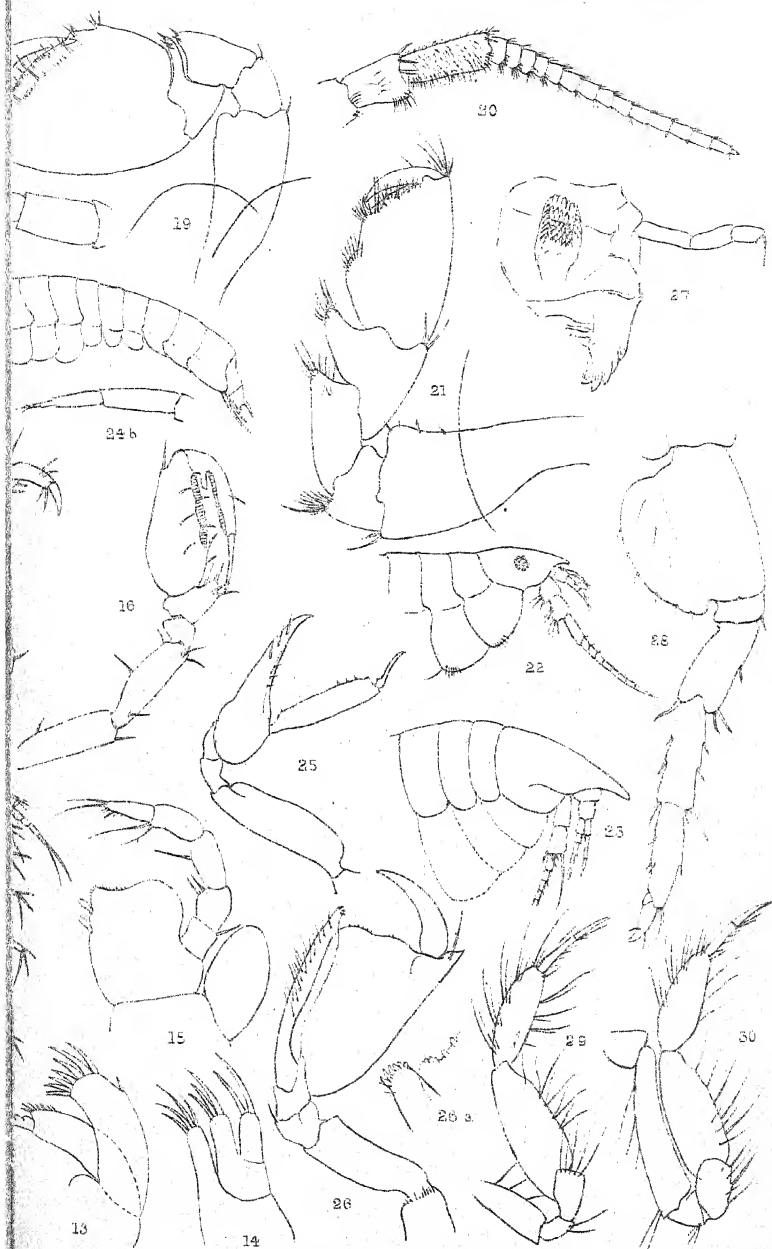
Mr. I. C. Thompson, F.L.S., has kindly named the under-mentioned species for me:—

<i>Calanus gracilis</i> .....	St. 3, 4.
<i>Pleuromma abdominale</i> .....	St. 3, 4.
<i>Acartia Clausii</i> .....	St. 4.
<i>Temora dubia</i> .....	St. 4.
<i>Euchæta marina</i> .....	St. 3.
<i>Eucalanus attenuatus</i> .....	St. 3.
<i>Oithona spinifrons</i> .....	St. 4.
<i>Corycæus obtusus</i> ...	St. 4.
<i>Thalestris rufocincta</i> .....	St. 3.
<i>Oncaea mediterranea</i> .....	St. 4.
<i>Porcellidium viride</i> .....	St. 4.





P. H. H. del. et lith.



West Newman imp.





## EXPLANATION OF PLATE 27.

- Fig. 1. *Mysidopsis ? serraticauda*, ♀. Upper antenna.  
 2. " " Lower antenna.  
 3. " " Mandible.  
 4. " " 2nd maxillipede.  
 5. " " Leg of the 1st (?) pair.  
 6. " " Telson and uropods.  
 6 a. " " Extremity of telson.  
 7. *Hyssura spinicauda*. Dorsal view.  
 8. " " Head.  
 9. " " Leg of the 2nd pair.  
 9 a. " " Do., part of the palm highly magnified.  
 10. " " Leg of the 1st pair.  
 11. " " Telson and uropods.  
 12. *Pleurocope dasyura*. Dorsal view.  
 13. " " 1st maxilla.  
 14. " " 2nd maxilla.  
 15. " " Maxillipede.  
 16. " " Leg of the 1st pair.  
 17. " " Leg of the last pair.  
 18. " " Operculum.  
 19. *Allorchestes aquilina*, ♂. 2nd gnathopod.  
 20. *Allorchestes plumicornis*, ♀. Lower antenna.  
 21. " " 2nd gnathopod.  
 22. *Metaphorus pectinatus*. Head, &c.  
 23. *Phoxus simplex*, Sp. Bate. Head, &c. From the type specimen in the British Museum.  
 24. *Leucothoë euryonyx*. Lateral view.  
 Figs. 24 a, 24 b. *Leucothoë euryonyx*. Upper and lower antennæ.  
 Fig. 25. *Leucothoë euryonyx*. 1st gnathopod.  
 26. " " 2nd gnathopod.  
 26 a. " " 2nd gnathopod, extremity of carpus, and angle of propodos.  
 27. *Paratylus guttatus*. Mandible.  
 28. " " 3rd pereopod.  
 29. *Melphidippa ?* sp. 1st gnathopod.  
 30. " " 2nd gnathopod.

On some British Freshwater Rhizopods and Heliozoa. By G. S. WEST, B.A., F.L.S. A.R.C.S., Hutchinson Student of St. John's College, Cambridge; Professor of Natural History at the Royal Agricultural College, Cirencester.

[Read 4th April, 1901.]

(PLATES 28-30.)

DURING the past few years I have been collecting and examining from every possible situation numerous small plants belonging to the Algæ, and amongst them I have found Rhizopods and Heliozoa in abundance. Most of the interesting forms of these groups I carefully sketched, in some instances making detailed and extended examinations of them, and I now possess an accumulation of notes and drawings, many of which may be deserving of notice.

Some of the observations in this paper relate to the habits and structure of certain of the Rhizopods and Heliozoa; others are descriptive of peculiar forms of the commoner and more abundant species; and others again are records of rarer and less-known species. I also give descriptions and figures of six animals which I believe have not previously been observed, one of which I have referred to a new genus (p. 325).

A point of considerable interest is the presence of a perforation at the apex of the shell of some forms of *Diffugia acuminata*, Ehrenb. The shell thus possesses two openings, one at each end, as in the case of those Rhizopods referred to the family *Amphistomina*.

As the remarkable animals belonging to the genus *Vampyrella* possess characters by which they are sharply demarcated from the other Rhizopods, I have placed them in a separate order—the *Vampyrellida*.

I have paid little attention to the species of *Amœba*, and it is very probable that I have overlooked several that are abundant and widely distributed.

## Class RHIZOPODA.

## Order AMŒBEA.

## Fam. LOBOSA.

## Gen. AMŒBA, Ehrenb.

1. AMŒBA PROTEUS, *Leidy*, in *Proc. Acad. Nat. Sci. Philad.* 1878, p. 99; *Freshw. Rhiz. N. Amer.* 1879, p. 31, t. i. ff. 1-8, t. ii. ff. 1-13.—*Volvox proteus*, *Pallas*, 1766. *Amœba princeps*, *Ehrenb. Abhandl. Akad. Wiss. Berlin*, 1831, pp. 28, 79; *Infus.* 1838, p. 126, t. viii. f. x.

Generally distributed; small forms most abundant. Some very large specimens were obtained from amongst *Utricularia minor* at Cocket Moss, near Giggleswick, W. Yorkshire. They possessed a very large elliptical nucleus, and were mostly gorged with Diatoms and Desmids.

2. AMŒBA VILLOSA, *Wallich*, in *Ann. Mag. Nat. Hist.* 1863, xi. p. 287, t. viii.; p. 366, t. ix.; p. 434, t. x. ff. 5-9.—*A. princeps*, *Carter*, in *Ann. Mag. Nat. Hist.* 1863, xii. pp. 30, 44, t. iii. ff. 1-3. *Trichamœba hirta*, *Fromontel*.

In a back-water of the R. Aire at "Seven Arches," near Bingley, W. Yorkshire, this species was in enormous abundance. The muddy bottom of the shallow water was covered with a thick black slime consisting entirely of *A. villosa*.

3. AMŒBA VERRUCOSA, *Ehrenb. Infus.* 1838, p. 126, t. viii. f. xi; *Carter*, in *Ann. Mag. Nat. Hist.* 1857, xx. p. 37, t. i. ff. 12, 13.—*A. natans*, *Perty*, 1852. *A. quadrilineata*, *Carter*, 1856. *Thecamœba quadripartita*, *Fromontel*.

A very abundant and widely distributed species. I obtained it in quantity amongst mosses at over 3000 ft. elevation on Snowdon, N. Wales.

## Gen. PELOMYXA, Greeff.

4. PELOMYXA PALUSTRIS, *Greeff*, in *Archiv für mikr. Anat.* 1870, x. pp. 51-72, t. iii.-v.

Length of animals approximately 500  $\mu$ .

Amongst *Sphagnum* in very stagnant water in a bog above the lakes at Capel Curig, N. Wales.

5. *PELOMYXA VILLOSA*, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 73, t. v., t. viii. ff. 31-33.—*Amœba sabulosa*, *Leidy*, 1874.

Terrington, N. Yorkshire, in ditches. Devil's Jumps, Frensham, Surrey, in bog-pools. Ashurst Bog, New Forest, Hants.

This is a smaller animal than *P. palustris*, Greeff, and possesses a terminal villous patch similar to that of *Amœba villosa*.

Gen. DACTYLOSPHERIUM, *Hertwig & Lesser*.

6. *DACTYLOSPHERIUM RADIOSUM*, *Blochmann, Die mikr. Thierwelt des Süßwass., I. Protozoa, Hamburg*, 1895, p. 14.—*Amœba radiosa*, *Ehrenb. Abh. Akad. Wiss. Berlin*, 1830, p. 80; *Infus.* 1838, p. 128, t. viii. f. xiii; *Carter, in Ann. Mag. Nat. Hist.* 1856, p. 243, t. v. ff. 10-18; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 58, t. iv. ff. 1-18. *A. brachiata*, *Dujardin*, 1841. *A. ramosa*, *Duj.*, 1841.

General in pools on heaths, and in bogs and pools in hilly districts.

A peculiar form was very abundant in the pools on Esher West-end Common, Surrey, in Feb. 1894. It had a spherical body of 12-19  $\mu$  in diameter, and five (sometimes six) long, attenuated pseudopodia. Length of pseudopodia 25-54  $\mu$ . I could find no trace of this form in the same locality in either of the two following years. (Pl. 28. fig. 5.)

The usual mountain form of the animal possesses a subspherical or ellipsoidal body, 32-50  $\mu$  in diameter, and from twelve to twenty long and exceedingly narrow pseudopodia. Length of pseudopodia 25-70  $\mu$ .

An extraordinary form was met with from Llyn Idwal, N. Wales. The body was more or less polygonal, 27-34  $\mu$  in diameter, and the pseudopodia were six in number, very slender, and of extraordinary length (52-107  $\mu$ ). (Pl. 28. fig. 4.)

7. *DACTYLOSPHERIUM VITREUM*, *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 54, t. ii. f. 1.

Shelf, West Yorkshire. Diameter of body 48-54  $\mu$ ; length of pseudopodia 29-48  $\mu$ .

All the animals possessed numerous radiating pseudopodia, seemingly entirely composed of the ectoplasm, the endoplasm extending a short way into their expanded bases. The ectoplasm

was homogeneous and very refractive. The endoplasm was dark-coloured and crowded with small granules; it also contained a well-marked nucleus and one contractile vacuole.

The genus *Dactylosphaerium* appears to be sufficiently well marked off from *Amœba*. The actual body of the animal is not strictly amœbiform, but always more or less spherical, sending out numbers of long, comparatively thin, attenuated pseudopodia. From what I have seen of these animals, I consider that *Dactylosphaeria* exhibit less active movements than *Amœba*. Some of the mountain forms of *D. radiosum* keep the same pseudopodia protruded to a variable extent for hours at a time.

### Fam. RETICULOSA.

#### Gen. GYMNOPHRYS, Cienk.

8. GYMNOPHRYS COMETA, Cienkowski, in *Archiv für mikr. Anat.* 1876, xii. p. 31, f. 25; Blochmann, *Die mikroskop. Thierwelt des Süßwass.*, I. Protozoa, Hamburg, 1895, p. 14, t. i. f. 9.

Near Brigg, Lincolnshire. (Pl. 28. fig. 3.) From this locality several specimens of an animal were obtained which may, perhaps, be Cienkowski's *Gymnophrys cometa*. The body was somewhat small, being about  $25\ \mu$  in length and  $18\ \mu$  in breadth, and some of them were distinctly constricted in the middle as if undergoing division. The pseudopodia varied in number from three to five at either end of the body, and sometimes reached a length of  $100\ \mu$ . They were delicate and hyaline, frequently much branched, and occasionally anastomosed with one another. The branches arose suddenly at a considerable angle from the main pseudopodial filament and exhibited a very rigid appearance. Small granules moved slowly along the pseudopodia, generally in groups.

Contractile vacuoles were entirely absent; this character and the peculiar nature of the rigidly-branched pseudopodia easily distinguishing it from *Biomysa vagans*, Leidy, a Rhizopod with which it possesses much affinity.

No nucleus could be detected in any of the individuals.

Archer (in *Qu. Jour. Micr. Sci.* 1877, xvii. p. 349) states that Cienkowski's species reminds him of "a portion of the mass of a *Gromia* become isolated and detached by some readily conceivable force, having wandered too far from the head-

quarters." Curiously enough, the collection in which I observed what I take to be the animal described by Cienkowski contained large numbers of a *Gromia*.

### Order TESTACEA.

#### Fam. ARCELLINA.

##### Gen. COCHLIOPODIUM, *Hertwig & Lesser*.

9. COCHLIOPODIUM BILIMBOSUM, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 184, t. xxxii. ff. 1-25.—*Amœba bilimbosa, Auerbach*, 1856. *Cochliopodium pellucidum, Hertwig & Lesser*, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 66, t. ii. f. 7.

I find this animal to be somewhat scarce. I have only obtained really good examples of it from five localities, viz.:—near Brigg, Lincolnshire; near Lough Neagh, Ireland; near Gortahork, Co. Donegal, Ireland; Llyn Ogwen, and the lakes at Capel Curig, N. Wales.

Diameter of shell 32-44  $\mu$ .

##### 10. COCHLIOPODIUM MINUTUM, sp. n. (Pl. 28. figs. 6-10.)

Very minute, with a cup-shaped delicate shell having an extremely wide mouth. Body-protoplasm granular; pseudopodia somewhat irregular, usually attenuated at the extremity. Nucleus absent. One or two vacuoles present in some individuals, but entirely absent in others.

Diameter of shell 12.4-13.5  $\mu$ .

Llyn-y-cwm-ffynon, N. Wales.

This small *Cochliopodium* was observed in abundance among numerous Desmids in washings of *Isoëtes*. The shell is very delicate, with a widely open mouth, and is structureless: it is also flexible, assuming various unsymmetrical shapes as it accommodates itself to the animal's movements. Seen from above the shell is usually circular, but it frequently exhibits an irregularly undulate margin.

The pseudopodia are commonly somewhat flattened extensions of colourless ectoplasm with distinctly attenuated ends. Sometimes they are flat, sheet-like expansions of irregular outline, which now and then fuse together, forming a bell-shaped ring of ectoplasm extending outwards from the edges of the mouth. In all cases they are colourless, hyaline projections showing no trace of any granulation. The animals, when active, extend

and retract these pseudopodia with considerable rapidity of movement.

The body-protoplasm within the shell is of a much darker hue than the pseudopodia, and, with the exception of a few instances in which it was homogeneous, exhibits a number of prominent granules. No nucleus was present in any of the individuals, but some possessed one or more vacuoles, which, however, were never observed to pulsate.

*C. minutum* is readily distinguished from *C. bilimbosum* by its minute size, its more delicate shell, and the absence of a nucleus. Moreover, it does not possess the punctate, expanded band of the shell in the region of the mouth.

11. *COCHLIPODIUM VESTITUM*, *Archer, in Qu. Jour. Micr. Sci.* 1876, p. 299; 1877, p. 334; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 188, t. xxxii. ff. 26-28.—*Amphizonella vestita*, *Archer, l. c.* 1871, xi. pp. 112, 135, t. vi. ff. 1-6. *Cochliopodium pilosum*, *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 78.

Esher West-end Common, Surrey. It occurred in great abundance in ditches and ponds among various Algæ: June-Aug. 1894-5. Diameter without spines 25-45  $\mu$ ; length of spines 3.7-5  $\mu$ . The majority of the individuals were colourless, but a few possessed chlorophyll granules.

Sheep's Green, Cambridge, July 1896, somewhat scarce. None of the individuals possessed any colouring-matter.

I am inclined to agree with Schulze (in *Archiv für mikr. Anat.* xi. p. 337) that the chlorophyll granules frequently found in individuals of this Rhizopod have been originally taken into the body-protoplasm as food.

12. *COCHLIPODIUM LONGISPINUM*, sp. n. (Pl. 28. fig. 1.)

Shell very thin and delicate, subspherical, with a broadly open, somewhat prominent mouth; exterior of shell covered with very long, extremely delicate, hair-like, radiating spines. Body-protoplasm granular, and with many highly-refractive globules. Nucleus large and round, situated towards the fundus. With one (or sometimes more) contractile vacuoles. Pseudopodia few broad and expansive, granular in the central part but hyaline and indistinct towards the edges.



Diameter of shell  $42\ \mu$ ; diameter of mouth of shell  $34\ \mu$ ; length of spines  $23\text{--}29\ \mu$ .

Wicken Fen, Cambridgeshire: July 1899, amongst *Chara hispida*.

The thin shell and the extremely long, delicate spines readily distinguish this species from *C. vestitum*, Archer. The spines are also more numerous than in the latter species, and the mouth of the shell is comparatively broader than in any specimen of *C. vestitum* I have seen. The pseudopodia are also thicker and more expansive, and the refractive globules from the body of the animal often pass into them. No green colouring-matter was obtained in any of the examples.

#### Gen. ARCELLA, Ehrenb.

13. ARCELLA VULGARIS, Ehrenb. *Abhand. Akad. Wiss. Berlin*, 1830, pp. 40, 53, etc. t. i. f. vi; *Infus.* 1838, p. 133, t. ix. f. v; Carter, in *Ann. Mag. Nat. Hist.* xviii. 1856, p. 128, t. vii. f. 79; 1864, xiii. p. 30, t. ii. f. 14.—A. hemisphærica, Perty, 1852. *Arcellina vulgaris*, Carter, 1856.

Generally distributed throughout the British Islands.

Var. GIBBOSA.—*Arcella vulgaris*, Leidy, *Freshw. Rhiz. N. Amer.* 1879, t. xxvi. ff. 23–24.—*Arcella gibbosa*, Penard, in *Mém. Soc. de Phys. et d'Hist. Nat. de Genève*, 1890, tome xxxi. no. 2, p. 155, t. v. ff. 96–99, t. vi. f. 1.

The convex surface of the shell faceted, the facets being circular depressions which fade away towards the edges of the shell. Shell dark brown in colour, sometimes nearly black.

In bogs, New Forest, Hants. In pools, Llangelynin, near Conway, N. Wales. Bog about two miles south of Clapham, W. Yorkshire.

From the last-named locality the specimens were very large, exceeding in dimensions any forms of the species I have yet come across. The diameter of the shell was in some cases as much as  $240\ \mu$ .

14. ARCELLA DISCOIDES, Ehrenb. *Monatsb. Akad. Wiss. Berlin*, 1843, p. 139; Leidy, *Freshw. Rhiz. N. Amer.* 1879, p. 173, t. xxviii. ff. 14–38.

Widely distributed, but not so abundant as *A. vulgaris*. At 2200 ft. on Glyder Fach, N. Wales.

15. *ARCELLA MITRATA*, *Leidy*, in *Proc. Acad. Nat. Sci. Philad.* 1876, p. 56; *Freshw. Rhiz. N. Amer.* 1879, p. 175, t. xxix.

A rare species which I have only obtained in abundance from the two following localities:—Cocket Moss, near Giggleswick, W. Yorkshire, amongst *Sphagnum* and *Utricularia minor*. Moel Siabod, N. Wales, in *Sphagnum*-pools.

Height of shell 100–145  $\mu$ ; diameter of shell 100–152  $\mu$ .

The mouth of the shell of this Rhizopod is inturned into the cavity of the shell, forming a short, broad, tube-like mouth. Leidy figures the pseudopodia as arising from the body-protoplasm at the inner end of this tube; but in all the living forms observed, a ventral column of protoplasm passed from the body-protoplasm into this tube, completely filling it up to the outer end. The pseudopodia then arose from the extreme ventral surface of this mass of protoplasm in the tube.

16. *ARCELLA ARTOCREA*, *Leidy*, in *Proc. Acad. Nat. Sci. Philad.* 1876, p. 57; *Freshw. Rhiz. N. Amer.* 1879, p. 178, t. xxx. ff. 1–9.

Bog above the lakes at Capel Curig, N. Wales.

Very large forms:—Diameter of shell (inclusive of rim) about 300  $\mu$ ; diameter of mouth 73  $\mu$ ; height of shell about 110  $\mu$ . Leidy gives 176  $\mu$  as his greatest breadth. (Pl. 28. fig. 2.)

Churchill, Co. Donegal, Ireland.

Diameter of shell about 85  $\mu$ .

I was unable to find any living specimens, all the shells being empty. The body of the shell was faceted, as in many of the more angular forms of *A. vulgaris*. It is apparently a very rare species, as I have never met with it from any other localities.

#### Gen. CENTROPYXIS, *Stein*.

17. *CENTROPYXIS ACULEATA*, *Stein*, *Sitz. böhm. Akad. Wiss.* 1857; *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 180, t. xxxi. ff. 1–32, t. xxxii. ff. 29–37.—*Arcella aculeata*, *Ehrenb. Abhand. Akad. Wiss. Berlin*, 1830, p. 40; 1841, p. 368, t. iii. f. 5. *Echinopyxis aculeata*, *Clap. & Lachm. Etudes Infus.* 1859, p. 447; *Carter*, in *Ann. Mag. Nat. Hist.* xiii. 1864, p. 29, t. i. f. 8.

This Rhizopod is very abundant and widely distributed, and the shell exhibits more variation than that of any other testaceous form. Some exceptionally large individuals were met with from near Athry Lough, W. Ireland, with a diameter of 450  $\mu$ .

without the spines. It was observed in many varied localities up to 3000 ft. on Snowdon, N. Wales, and 3000 ft. in Scotland.

Although this animal was first described by Ehrenberg as a species of *Arcella*, and is yet regarded as such by some authors, I think there can be no doubt that it bears a closer resemblance to *Diffugia constricta* than to any other testaceous Rhizopod. Leidy points this out most clearly, and gives illustrations of numerous intermediate forms, and Blochmann also comments upon it.

From near Knaresborough and from near Giggleswick, W. Yorkshire, a large number of small examples were seen with the shells composed of sand-grains. The shells were very much oblique, and possessed three smooth, chitinous spines at the fundus, each spine being sharply apiculate. Diameter of shell  $63\ \mu$ ; length of spines  $25\ \mu$ .

A peculiar form was met with from Widdale Beck, N. Yorkshire, with fourteen spines arranged in an arc, those at the fundus being very short, and those towards the mouth very long. Diameter of shell without spines  $190\ \mu$ .

Some striking forms were observed from Terrington, N. Yorkshire. The shells were thin, chitinous, and almost transparent. Diameter of shell  $120\ \mu$ . Three short, thick spines were present, each spine being perforated at the apex. Thus, in addition to the mouth of the shell, there were three open, tubular passages placing the interior of the shell in communication with external surroundings. Owing to the thinness and transparency of the shells, I was enabled to carefully examine the structure of the chitinous membrane of which they were composed. Leidy remarks (*loc. cit.* p. 183) that "while spineless specimens of *Centropyxis*, composed of chitinous membrane, approximate to *Arcella* in character, I never could satisfy myself that the shell of the former exhibited the cancellated structure of the latter. In some chitinous shells of *Centropyxis* I have observed a punctated appearance of some uniformity, but it did not display the clear cancellated arrangement so characteristic of the shell of *Arcella*."

The chitinous membrane composing the shells of the Terrington forms was of a pale yellow colour and minutely scrobiculate. The scrobiculations were irregularly disposed, being scattered more or less in groups, and between them were numerous much

smaller punctulations. The structure of the shell-membrane of the particular forms described was thus of a somewhat different nature from the cancellated structure exhibited by the shells of *Arcella*. (Cfr. Pl. 29. figs. 15, 16.)

Var. *ECORNIS*, *Leidy*, *l. c.* p. 180, t. xxx. ff. 20-34, t. xxxi. ff. 33, 34.—*Arcella ecornis*, *Ehrenb. Abhand. Akad. Wiss. Berlin*, 1841, p. 368, t. i. f. 9, t. iii. f. 46. *Centropyxis lævigata*, *Penard*, in *Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 151. t. v. ff. 42-44, 49-55.

Not so abundant as the typical spined form. Obtained it very abundantly on damp moss on limestone rocks, Ingleton, N. Yorkshire. Also from near Bowness, Westmoreland.

#### Gen. DIFFLUGIA, *Leclerc*.

18. DIFFLUGIA CONSTRICTA, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 120, t. xviii.—*Arcella constricta*, *Ehrenb. Abhand. Akad. Wiss. Berlin*, 1841, p. 410, t. iv. f. 35, t. v. f. 1. *Difflugia marsupiformis*, *Wallich*, in *Ann. Mag. Nat. Hist.* xiii. 1864, pp. 241, 244, t. xvi. ff. 3-5. *D. platystoma*, *Penard*, in *Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 143, t. iv. ff. 35-37.

A very abundant species which exhibits much variation, many of the forms being practically indistinguishable from *Centropyxis aculeata* var. *ecornis*. The highest elevation at which I obtained it was 3000 ft. on Snowdon, N. Wales.

19. DIFFLUGIA PYRIFORMIS, *Perty*, 1848; *Kennt. kleinst. Lebensf.* 1852, p. 187, t. ix. f. 9; *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, t. x., xi., xii. ff. 1-18, etc.—*D. compressa*, *Carter*, in *Ann. Mag. Nat. Hist.* xiii. 1864, p. 22, t. i. ff. 5, 6. *D. entochloris*, *Leidy*, in *Proc. Acad. Nat. Sci. Philad.* 1874, p. 79; 1875, p. 307. *D. saxicola*, *Penard*, in *Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 138, t. iii. ff. 50-53. *D. avellana*, *Penard*, *l. c.* p. 144, t. iv. ff. 38-40. *D. fallax*, *Penard*, *l. c.* t. iv. ff. 41-51. *D. lucida*, *Penard*, *l. c.* p. 145, t. iv. ff. 52-58. *D. bacillifera*, *Penard*, et var. *inflata*, *Penard*, *l. c.* p. 46, t. iv. ff. 61-71. *D. lanceolata*, *Penard*, *l. c.* p. 145, t. iv. ff. 59, 60.

The most widely distributed species of the genus, especially in quiet waters. It is subject to very great variation, not only in outward form, but also in the nature of the materials composing

the shell. Only once have I obtained it from wet rocks, and that was at an elevation of 3000 ft. on Snowdon, N. Wales.

The three following are the most noteworthy forms I have met with:—

From a bog near Widdale Beck, N. Yorkshire, numerous large specimens were noticed with thin chitinoid shells with which were incorporated very large Diatoms (*Navicula viridis* and *N. major*). Precisely similar forms were noticed in which the shells consisted almost entirely of Diatoms (*Vanheurnkia rhomboides* and *Navicula divergens*) from near Clapham, W. Yorkshire, and from Mickle Fell, N. Yorkshire.

From Lough Shannacloontippen and Ballynahinch, W. Ireland, numbers of minute forms of this Rhizopod were observed. The shell was chitinoid, of a pale yellow colour, and a few sand-grains were attached irregularly at the fundus. The same form was noticed from Capel Curig, N. Wales, except that the chitinous shell was colourless. Length of shell 29–30  $\mu$ ; breadth 18–24  $\mu$ . (Pl. 28. figs. 13, 14.)

From Llyn Idwal, N. Wales, the forms possessed long slender necks, and the shell was composed of exceptionally large sand-grains. The same form was also obtained from Cockett Moss, near Giggleswick, W. Yorkshire. Length of shell about 250  $\mu$ ; breadth 46  $\mu$ .

Var. *vas*, *Leidy*, Freshw. Rhiz. N. Amer. 1879, p. 99, t. xii. ff. 2–9.—*D. vas*, *Leidy*, in Proc. Acad. Nat. Sci. Philad. 1874, p. 155; 1875, p. 307.

Not uncommon, but rarely so abundant as more typical forms of *D. pyriformis*. The peculiar neck of this variety is very characteristic.

The largest forms seen were from the New Forest, Hants. Length of shell 470  $\mu$ ; breadth 380  $\mu$ ; breadth of neck 100  $\mu$ .

Some peculiar forms were seen from Llyn Idwal, N. Wales, in which the sand-grains composing the neck were quite transparent and colourless, whereas those composing the body of the shell were yellow and opaque. Length 460  $\mu$ ; breadth 300  $\mu$ .

20. *DIFFLUGIA URCEOLATA*, *Carter*, in *Ann. Mag. Nat. Hist.* xiii. 1864, pp. 27, 37, t. i. f. 7; *Leidy*, l. c. p. 106, t. xiv.—*D. lageniformis*, *Wallich*, in *Ann. Mag. Nat. Hist.* xiii. 1864, p. 240, t. xiv. ff. 15, 16.

A rare species, which I have only obtained copiously from Bowness, Westmoreland.

21. *DIFFLUGIA ACUMINATA*, Ehrenb. *Infus.* 1838, p. 131, t. ix. f. 3; *Leidy, l. c.* p. 109, t. xiii.—*D. bacillarium*, Perty.

An abundant and widely distributed species, which I have observed up to 2200 ft. on Glyder Fach, N. Wales.

Var. *AMPHORA*.—*D. amphora*, Penard, in *Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 139, t. iii. ff. 55-65. Not *D. amphora*, Leidy (which is a variety of *D. urceolata*).

Differs from typical *D. acuminata* in the upper portion of the shell being acutely conical but not acuminate.

This variety frequently possesses a shell consisting of a thin chitinous membrane incorporated with Diatoms. *Cfr.* Leidy, *l. c.* t. xiii. ff. 23-26. Such forms were very abundant from Cocket Moss, near Giggleswick, W. Yorkshire, and in all cases the Diatom was *Vanheurckia rhomboides* var. *saxonica*.

Var. *ELEGANS*.—*D. elegans*, Penard, *l. c.* p. 140, t. iv. ff. 4-11.

A small variety with the acuminate apex of the shell tube-like and perforated. Length of shell 94-100  $\mu$ ; breadth of shell 52-58  $\mu$ ; breadth of mouth 27-31  $\mu$ . (Pl. 28. figs. 11-12.)

Wicken Fen, Cambridgeshire. Llyn-y-cwm-fynon, N. Wales.

The shells of this variety are generally chitinous, pale yellow or brown in colour, and they may or may not be encrusted with a variable amount of sand-grains. The body of the animal is quite normal, and is supported towards the apex of the shell by the usual, protoplasmic, stay-like projections. The actual apex of the shell is drawn out into a long tube, which is frequently bent at a considerable angle to one side, and the end of this tube is open. I have never observed any exudation of protoplasm into this tube, the body of the animal being somewhat removed from its base. As the shell possesses two openings, one at each end, it is quite comparable to shells like *Ditrema* and *Amphitrema*, which are placed in the family *Amphistomina*, although in the *Diffugia* only one aperture is utilized for the protrusion of pseudopodia.

Occasionally a few Diatoms are incorporated into the shell, and one instance was noticed in which a number of living Diatoms were attached to it.

22. *DIFFLUGIA CORONA*, Wallich, in *Ann. Mag. Nat. Hist.* 1864, xiii. t. xv. ff. 19, 20; Leidy, *Freshw. Rhiz. N. Amer.* 1879, p. 117, t. xvii.

A rare species which I have only observed from Llyn Llydaw, Snowdon, and in pools, Y Foel Fras, N. Wales. In all the specimens observed the spines were very robust. Length of shell 150–160  $\mu$ ; breadth (including spines) 165–182  $\mu$ ; breadth of mouth 75  $\mu$ .

23. *DIFFLUGIA GLOBULOSA*, Dujardin, in *Ann. Sci. Nat.* 1837, viii. p. 311, t. ix. f. 1 a, b; Leidy, l. c. p. 96, t. xv. ff. 25–31; t. xvi. ff. 1–24. *D. globularis*, Wallich, in *Ann. Mag. Nat. Hist.* xiii. 1864, p. 241, t. xvi. ff. 1, 2, 17, 27. *D. acropodia*, Hertwig & Lesser, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 107, t. ii. f. 6.

A general and widely distributed species, exhibiting considerable variation in size and form. I have obtained it at 2700 ft. on Glyder Fawr, and at 3000 ft. on Snowdon, N. Wales.

The smallest forms observed were from Roundhay Park, W. Yorkshire. The shells were straw-coloured and slightly asperulate; diam. 13.5–17  $\mu$ ; diam. of mouth 5.7  $\mu$ . (Pl. 29. figs. 17, 18.)

Another small form, which was abundant from Lough Guitane and Torc Mt., S.W. Ireland, possessed a yellow, chitinous shell with an exceptionally wide mouth. Diam. 38  $\mu$ ; diam. of mouth 29–33  $\mu$ .

Two specimens were observed conjugating from Cocket Moss, near Giggleswick, W. Yorkshire. From this locality the animals possessed a perfectly globose, colourless chitinous shell, attached to which were a few sand-grains and numerous large Diatoms. The mouth was relatively very small. Diam. 190  $\mu$ ; diam. of mouth 52  $\mu$ .

24. *DIFFLUGIA LOBOSTOMA*, Leidy, in *Proc. Acad. Nat. Sci. Philad.* 1874, p. 79; 1877, p. 307; *Freshw. Rhiz. N. Amer.* 1879, p. 112, t. xv. ff. 1–24, t. xvi. ff. 25–29.—*D. crenulata*, Leidy, 1874.

Somewhat scarce. Diameter of shell 49–285  $\mu$ .

Form with a three-lobed mouth observed from Carlton Bank, N. Yorkshire; Llyn Cwlyd and Capel Curig, N. Wales.

Form with a five-lobed mouth observed from near Sedbergh, W. Yorkshire. These specimens were very much larger than any previously recorded.

Gen. LECQUEREUSIA, *Schlumberger*.

25. LECQUEREUSIA SPIRALIS, *Blochmann*, *Die mikr. Thierwelt des Süßwass.*, I. *Protozoa*, Hamburg, 1895, p. 17.—*Diffugia spiralis*, *Ehrenb.* 1840; *Abhand. Akad. Wiss. Berlin*, 1871, p. 274, t. iii. ff. 25–27; *Pritch. Infus.* 1861, p. 553. *Lecquereusia jurassica*, *Schlumb.* in *Ann. Sci. Nat.* 1845, p. 255. *Diffugia Helix*, *Cohn*, in *Zeitschr. f. wissenschaft. Zool.* 1853, p. 261.

Generally distributed and abundant. The amount of coiling of the shell and the nature of the materials composing it vary considerably. The forms possessing a shell composed entirely of sand-grains are somewhat rare.

Gen. NEBELA, *Leidy*.

26. NEBELA COLLARIS, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 145, t. xxii.; t. xxiii. ff. 1–7; t. xxiv. ff. 11, 12.—*Diffugia collaris*, *Ehrenb. Monatsb. Akad. Wiss. Berlin*, 1848, p. 218. *D. peltigeracea*, *Carter*, in *Ann. Mag. Nat. Hist.* xiii. 1864, t. i. f. 12. *D. symmetrica*, *Wallich*, in *Ann. Mag. Nat. Hist.* xiii. 1864, t. xvi. ff. 27–33. *Nebela militaris*, *Penard*, in *Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 164, t. vii. ff. 16–22.

Widely distributed, especially in *Sphagnum*-bogs. Up to 2000 ft. on Glyder Fach, and 2700 ft. on Glyder Fawr, N. Wales. In *Sphagnum*-pools, Orkney Is.

Var. LAGENIFORMIS.—*N. lageniformis*, *Penard*, l. c. p. 158, t. vi. ff. 50–61. *N. ambigua*, *Cash*, in *Trans. Manchester Micr. Soc.* 1891, p. 50, t. ii. f. 17.

This variety is distinguished by its more elegant outline and prominent neck. In habit, structure of shell, etc. it is precisely similar to typical *N. collaris*. Length of shell 115–123  $\mu$ ; breadth of shell 63–70  $\mu$ ; breadth of mouth 25–27  $\mu$ .

A less frequent form than the type, and one which I have only obtained in quantity from pools on Penyghent, W. Yorkshire, and from Capel Curig, N. Wales.



27. *NEBELA FLABELLULUM*, Leidy, in *Proc. Acad. Nat. Sci. Philad.* 1876, p. 118, ff. 6, 7; 1877, p. 264; *Freshw. Rhiz. N. Amer.* 1879, p. 152, t. xxiii. ff. 8-19.

Not so abundant as the preceding species; often found amongst mosses on dripping rocks. Up to 2700 ft. on Glyder Fawr N. Wales.

28. *NEBELA DENTISTOMA*, Penard, in *Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 162, t. vi. ff. 98-100; t. vii. ff. 1-5.—*N. crenulata*, Cash, in *Trans. Manchester Micr. Soc.* 1891, p. 50, t. ii. f. 18.

Length of shell 108-113  $\mu$ ; max. breadth of shell 82-88  $\mu$ ; breadth of mouth 36-38  $\mu$ ; thickness 42  $\mu$ .

Amongst *Philontis fontana* in springs at 2700 ft. on Glyder Fawr, N. Wales.

This species, which is either rare or overlooked, is completely different in outward form from *N. collaris*, the only species with which it could be confounded. Except for the mouth, it is a perfect oval in shape, and that orifice appears as a chord cutting off the narrower end. There is not even the faintest suspicion of a neck, and the mouth is considerably wider than in any form of *N. collaris*. The specific name refers to the nature of the mouth, and therein lies the character which at once distinguishes *N. dentistoma* from *N. collaris*. The mouth of the shell of the former species always presents a crenulate appearance, owing to the irregular disposition of the small plates composing the shell, whereas the mouth of the latter species is perfectly smooth and sometimes slightly thickened. The ratio of the breadth of the mouth to the breadth of the shell in *N. dentistoma* averages 1:2.3, whereas in *N. collaris* it averages 1:2.8.

29. *NEBELA CARINATA*, Leidy, in *Proc. Acad. Nat. Sci. Philad.* 1876, p. 118, ff. 10, 11; *Freshw. Rhiz. N. Amer.* 1879, p. 154, t. xxiv. ff. 1-10.—*Diffugia carinata*, Archer, 1866; in *Qu. Jour. Micr. Sci.* 1869, ix. t. xx. f. 12.

Although widely distributed this species is not abundant. It is usually found amongst *Sphagnum*. I obtained numerous examples from some deep *Sphagnum*-pools at 2200 ft. on Glyder Fach, N. Wales.

30. NEBELA HIPPOCREPIS, *Leidy, Rhiz. N. Amer.* 1879, p. 156, t. xxv. ff. 9-14.

Length of shell  $183\ \mu$ ; breadth  $133\ \mu$ ; breadth of mouth  $29\ \mu$ .

Amongst wet *Sphagnum* below the outlet of Llyn Idwal, N. Wales.

Only one specimen of this rare species was observed, and it was an old, empty shell. The digitate processes of the carina which pass down into the cavity of the shell are unique and unmistakable. It has only previously been found in New Jersey.

Blochmann suggests that it is the same species as *N. bigibbosa*, Penard, but on careful comparison the two shells are seen to be of quite a different nature, *N. bigibbosa* being entirely devoid of a keel. A species which may, however, ultimately prove to be *N. hippocrepis* is *N. galeata*, Penard, but Penard's figures are too indistinct for one to form any definite opinion.

31. NEBELA BARBATA, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1876, p. 119, f. 8; *Freshw. Rhiz. N. Amer.* 1879, p. 159, t. xxiv. ff. 14-17.

Llyn Llydaw, Snowdon, N. Wales. A number of minute sand-grains were attached to the shell. Length  $198\ \mu$ ; breadth  $50\ \mu$ ; length of spines about  $15\ \mu$ .

#### Gen. HELEOPERA, *Leidy*.

32. HELEOPERA PICTA, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 162, t. xxxi. ff. 1-11.—*Diffugia sphagni*, *Leidy*, 1874. *Nebela sphagni*, *Leidy*, 1876.

Not uncommon in *Sphagnum*-pools and bogs. Frequently met with in the encysted condition.

33. HELEOPERA PETRICOLA, *Leidy, l. c.* p. 165, t. xxvi. ff. 12-20.

A much scarcer species than *H. picta*. Bog near Widdale Beck, N. Yorkshire. Hawkshead, Lancashire. Capel Curig, N. Wales. Near Glenties, Co. Donegal, Ireland. Orkney Is.

#### Gen. QUADRULA, *F. E. Schulze*.

34. QUADRULA SYMMETRICA, *F. E. Schulze, in Archiv für mikr. Anat.* 1875, p. 329, t. xviii. ff. 1-6; *Archer, in Qu. Jour. Micr. Sci.* 1877, p. 122.—*Diffugia symmetrica*, *Wallich, in Ann. Mag. Nat. Hist.* xiii. 1864, p. 245. *D. assulata*, *Ehrenb* 1871.

Widely distributed, but rarely abundant. Not uncommon amongst *Sphagnum* in peaty pools and bogs; also amongst mosses on wet rocks.

I have noticed a small form of this animal in which the oral end of the shell is produced into a neck of considerable length. The chitinous plates composing the shell are also polygonal in form and more numerous. Length of shell  $63-68\mu$ ; breadth of shell  $28-33\mu$ ; breadth of neck  $10-14\mu$ . Bowness, Westmoreland, and Moel Siabod, N. Wales.

35. *QUADRULA IRREGULARIS*, Archer, in *Qu. Jour. Micr. Sci.* xvii. 1877, p. 113.—*Q. monensis*, Cash, in *Trans. Manchester Micr. Soc.* 1891, p. 50, t. ii. ff. 14-16.

Among mosses in a mountain-stream, Penyghent, W. Yorkshire. Length of shell  $35\mu$ ; breadth of shell  $36\mu$ ; breadth of mouth  $13\mu$ ; thickness  $23\mu$ . (Pl. 29. figs. 19, 20.)

Not more than two or three specimens of this interesting species were observed, but the shell is so characteristic and its aspect so different from that of *Q. symmetrica*, that it is impossible to confuse them. The plates composing the shell (or test) were comparatively regular in outline and arrangement, being approximately square and more or less arranged in oblique series. It agrees very well with Archer's description in being "smaller than *Q. symmetrica*, quite without any neck, the 'mouth' being where a small chord seems, as it were, cut off the globular, or perhaps somewhat compressed test, nor are there any 'lips' nor even any evident thickened margin." Archer states that the plates composing the test are arranged in longitudinal rows, but in the few specimens observed the rows of plates were slightly oblique. He also says: "mouth subcircular in outline," whereas the mouth of the Yorkshire specimens was almost narrowly elliptical. This fact is immaterial, however, if the usual allowance be made for the variation which is so striking a feature of the testaceous Rhizopods. The specimens observed were undoubtedly identical with *Q. monensis*, and, moreover, they also agreed with Cash's description in possessing an elliptical mouth and obliquely disposed plates. But as I am firmly convinced that *Q. monensis* is the same species of Rhizopod as that named *Q. irregularis* by Archer nineteen years previously, the latter name takes precedence.

Gen. HYALOSPHENIA, *Stein*.

36. HYALOSPHENIA CUNEATA, *Stein*, *Sitzungsb. böhm. Akad. Wiss.* 1857; *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 129, t. xx. ff. 1-10.—*H. lata*, *Schulze*, in *Archiv für mikr. Anat.* 1875, xi. p. 335, t. xviii. ff. 15-18; *Archer*, in *Qu. Jour. Micr. Sci.* 1877, p. 110.

Cocket Moss, near Giggleswick, W. Yorkshire. Large specimens with a relatively broad mouth to the shell. Length of shell  $75\ \mu$ ; breadth of shell  $60\ \mu$ ; breadth of mouth  $31\ \mu$ .

River Ballanderry near its entrance into Lough Neagh, Ireland. Small specimens with a faint indication of a neck to the shell, the mouth of which is relatively small. Numbers of specimens were examined in a very active state, and each possessed two contractile vacuoles. The nucleus in these Irish specimens was comparatively small. Length of shell  $56-62\ \mu$ ; breadth  $40-44\ \mu$ ; breadth of mouth  $13-14\ \mu$ ; thickness  $16\ \mu$ . (Pl. 29. figs. 21, 22.)

37. HYALOSPHENIA ELEGANS, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 140, t. xx. ff. 19-29.—*Diffugia* (Catharia) *elegans*, *Leidy*, in *Proc. Acad. Nat. Sci. Philad.* 1874, p. 156.

This species I have only observed among *Sphagnum* at Cocket Moss, near Giggleswick, W. Yorkshire.

## LEPTOCHLAMYS, gen. n.

Shell ovoid, slightly oblique, consisting of a thin, transparent, structureless, chitinoid membrane; narrower or ventral end of shell slightly produced and minutely expanded, terminating in a mouth which is often placed a little obliquely; vertical view of shell circular; mouth circular. Protoplasmic body completely filling the shell; nucleus very large and situated dorsally. With a single, short pseudopodium, broadly expanded and sometimes cordate. Vacuoles entirely absent.

38. LEPTOCHLAMYS AMPULLACEA, sp. unica. (Pl. 29. figs. 23-26.)

Small; body composed of finely granular protoplasm, containing a large punctate nucleus at the pole away from the mouth; both green and brown food-particles present in the body-protoplasm. With a single pseudopodium (sometimes a faint indication of two), well differentiated into a lobe of dull

grey endoplasm enveloped in a larger mass of clear transparent ectoplasm.

Length of shell 48–55  $\mu$ ; diameter of shell 36–40  $\mu$ ; diameter of mouth 15–17  $\mu$ .

This interesting Rhizopod was abundant among various Algae and *Isoëtes*, in the shallow water at the margins of Llyn-y-cwm-ffynon, Glyder Fawr, N. Wales.

The structureless shell at first reminds one of *Hyalosphenia*, but, apart from the entirely different nature of the animal, the shell is at once distinguished from shells of that genus by its circular cross-section and circular mouth. It is a thin, transparent, chitinoid shell, generally somewhat obliquely ovoidal (or ellipsoidal), and possesses a slightly expanded, minutely bell-shaped mouth at the narrower or ventral pole. The shell is quite firm and rigid, and the body-protoplasm of the animal completely fills it, fitting closely to the inner surface.

The nucleus, which, as compared with that of other lobose Rhizopods, is exceedingly large, is situated towards the extreme dorsal pole of the shell, and exhibits a finely punctate appearance. The body-protoplasm is of a dull grey colour, and is filled with granules of variable magnitude, more especially in the region immediately ventral to the nucleus. Various food-particles in different stages of digestion are noticeable in almost every individual, the animals feeding largely on unicellular Palmellaceæ. The method of feeding is quite normal.

One of the most remarkable features of *Leptochlamys* is the extraordinary pseudopodium. On the protrusion of the pseudopodium the animal first exudes from the mouth of the shell a more or less globular mass of ectoplasm, which is transparent and very hyaline in appearance. This is followed by an exudation of slightly darker-coloured, homogeneous endoplasm. The pseudopodium is quite a large mass, ever changing its shape, but never at any time becoming divided into two pseudopodia. At most, it becomes retuse at the broad, distal end, and at all times there is a well-marked separation into ectoplasm and endoplasm.

No vacuoles (contractile or otherwise) were observed in any of the animals, and so far as I could ascertain they were absent.

The genus is undoubtedly nearest to *Cryptodiffugia*, Penard (in Mém. Soc. Phys. et d'Hist. Nat. Genève, tom. xxxi. no. 2, 1890, p. 168, t. vii. ff. 95–107), but is readily distinguished by

the different mouth of the shell, and the nature of the animal and its pseudopodia.

Fam. EUGLYPHINA.

Gen. EUGLYPHA, *Dujardin*.

39. EUGLYPHA ALVEOLATA, *Dujardin*, *Infusoires*, 1841, p. 252, t. ii. ff. 9, 10; *Hertwig & Lesser*, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 124, t. iii. f. 5; *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 207, t. xxxv. ff. 1-18.—*Diffugia areolata*, *Ehrenb.* *D. acanthophora*, *Ehrenb.* *Euglypha tuberculata*, *Duj.* *E. lævis*, *Perty.* *E. minima*, *Perty.*

Generally distributed and often abundant. Very variable in the form of the shell and in the plates composing it. The young forms were described by Perty as *E. lævis* and *E. minima*.

Some very large forms were noticed from Puttenham Common, Surrey; there were four strong spines in the dorsal region of the shell. Length of shell  $154\mu$ ; breadth  $80\mu$ .

It was obtained abundantly at 2700 ft. on Glyder Fawr, N. Wales.

40. EUGLYPHA CILIATA, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 214, t. xxxv. ff. 19, 20; t. xxxvi.; t. xxxvii. ff. 30, 31.—*Diffugia ciliata*, *Ehrenb. Monatsb. Akad. Wiss. Berlin*, 1848, p. 379. *Euglypha compressa*, *Carter*, in *Ann. Mag. Nat. Hist.* 1864, xiii. p. 32, t. i. f. 13; *Schulze*, in *Archiv für mikr. Anat.* 1875, xi. p. 101, t. v. ff. 3, 4.

Generally distributed, but not so abundant as the preceding species. The forms noticed with the largest spines were from the New Forest, Hants. It was obtained at 2700 ft. on Glyder Fawr, N. Wales, and conjugating examples were observed from Moel Siabod, N. Wales.

Var. STRIGOSA.—*Diffugia strigosa*, *Ehrenb.* *Euglypha strigosa*, *Leidy*, in *Proc. Acad. Nat. Sci. Philad.* 1878, p. 172; *Penard*, in *Mém. Soc. Phys. et d'Hist. Nat. Genève*, tom. xxxi. no. 2, 1890, p. 179, t. ix. ff. 58-68.

I have only occasionally met with the forms with more or less diffuse, hair-like spines, which are included in this variety. Bowness, Westmoreland. Bog near Widdale Beck, N. Yorkshire. Richmond Park, Surrey. Llyn Ogwen, N. Wales. Orkney Is.

41. *EUGLYPHA MUCRONATA*, *Leidy*, in *Proc. Acad. Nat. Sci. Philad.* 1878, p. 172; *Freshw. Rhiz. N. Amer.* 1879, p. 219, t. xxxvii. ff. 11-14.

A rare species, which I have only met with amongst *Sphagnum* at Hawkshead, Lancashire.

One specimen was noticed in which there were two spines, one at the extreme apex, and the other some little distance below it. Length of shell (without spine)  $123\ \mu$ ; breadth  $60\ \mu$ .

42. *EUGLYPHA BRACHIATA*, *Leidy*, in *Proc. Acad. Nat. Sci. Philad.* 1878, p. 172; *Freshw. Rhiz. N. Amer.* 1879, p. 200, t. xxxvii. ff. 5-10.

Capel Curig, N. Wales. Small lakes E. of Recess, W. Ireland. Length of shell about  $120\ \mu$ ; breadth about  $32\ \mu$ .

This is another rare species of the genus, which I have only obtained twice, and in both instances from submerged *Sphagnum*. It was described by *Leidy* from New Jersey.

#### Gen. PLACOCYSTA, *Leidy*.

43. *PLACOCYSTA SPINOSA*, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 221, t. xxxviii.—*Euglypha spinosa*, *Carter*, in *Ann. Mag. Nat. Hist.* 1865, xv. p. 290, t. xii. f. 13; *Archer*, in *Qu. Jour. Micr. Sci.* 1872, xii. p. 90.

Somewhat rare. Length of shell  $120-127\ \mu$ ; breadth  $96-100\ \mu$ ; breadth of mouth  $50-54\ \mu$ ; thickness about  $38\ \mu$ .

Scarce in a bog near Bowness, Westmoreland. Hawkshead, Lancashire. Llyn Llydaw, Snowdon, N. Wales: dead shells not uncommon, but no living animals seen. It is recorded as occurring in N. Wales in *Qu. Jour. Micr. Sci.* 1876, xvi. p. 237, but described as "very rare indeed."

The form of the shell and the wide mouth with perfectly smooth edges are characters sufficient to distinguish this genus from *Euglypha*.

#### Gen. SPHENODERIA, *Schlumberger*.

44. *SPHENODERIA LENTA*, *Schlumberger*, in *Ann. Sci. Nat.* 1845, p. 256; *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 229, t. xxxiv. ff. 25-41.—*Euglypha globosa*, *Carter*, in *Ann. Mag. Nat. Hist.* 1865, xv. p. 290, t. xii. f. 14; *Hertwig & Lesser*, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 129, t. iii. f. 7.

Generally distributed throughout the British Islands. The

largest forms observed were from Wrynose, Lancashire. Length of shell  $65\ \mu$ ; diameter of shell  $54\ \mu$ .

Var. *FISSIROSTRA*.—*Sphenoderia fissirostris*, Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève, tom. xxxi. no. 2, 1890, p. 184, t. x. ff. 30-40.

Body of shell elliptic-ovoid; plates near the fundus round, but larger and elliptical towards the mouth. Length of shell  $46\ \mu$ ; breadth  $23\ \mu$ ; diameter of mouth  $13.5\ \mu$ . Llyn Bochlwyd, N. Wales. Orkney Is.

The only difference between this form and typical *Sphenoderia lenta* is the presence of the larger, elliptical plates near the mouth, and this is insufficient as a specific distinction.

The genus *Sphenoderia* is not recognized by Blochmann (Die mikr. Thierwelt des Süßwass., I. Protozoa, Hamburg, 1895, p. 18), who merges it with the genus *Euglypha*. Personally, I think the narrow chitinous mouth, which is quite devoid of the plates of which the remainder of the shell is composed, is a very good generic character, and one which at once distinguishes *Sphenoderia* from *Euglypha*.

#### Gen. ASSULINA, Ehrenb.

45. *ASSULINA SEMINULUM*, Ehrenb. 1871; Leidy, *Freshw. Rhiz. N. Amer.* 1879, p. 225, t. xxxvii. ff. 15-27.—*Diffugia seminulum*, Ehrenb. *Monatsb. Akad. Wiss.* 1848, p. 379. *Euglypha brunnea*, Leidy, 1874. *E. tinctoria*, Archer, 1875.

General amongst *Sphagnum* and on wet rocks. Up to 3500 ft. on Lochnagar, Scotland. Orkney Is.

#### Gen. TRINEMA, Dujardin.

46. *TRINEMA ENCHELYS*, Leidy, in *Proc. Acad. Nat. Sci. Philad.* 1878, p. 172; *Freshw. Rhiz. N. Amer.* 1879, p. 227, t. xxxix.—*Diffugia enchelys*, Ehrenb. *Infus.* 1838, p. 132, t. ix. f. 4. *Arcella hyalina*, Ehrenb. *Trinema acinus*, Dujardin, *Infusoires*, 1841, p. 249, t. iv. f. 1. *Trinema complanatum*, Penard. *T. lineare*, Penard.

Probably the commonest and most widely distributed of testaceous Rhizopods, occurring abundantly in all kinds of damp and wet situations. The largest forms noticed were from Mickle Fell, N. Yorkshire, and it was observed up to 2700 ft. on Glyder Fawr, N. Wales.



Gen. CYPHODERIA, *Schlumberger*.

47. CYPHODERIA AMPULLA, *Leidy*, in *Proc. Acad. Nat. Sci. Philad.* 1878, p. 173; *Freshw. Rhiz. N. Amer.* 1879, p. 202, t. xxxiv. ff. 1-16.—*Diffugia ampulla*, *Ehrenb.* 1840; *Abhandl. Akad. Wiss.* 1871, t. iii. f. 11. *Cyphoderia margaritacea*, *Schlumberger*, in *Ann. Sci. Nat.* 1845, iii. p. 255; *Hertwig & Lesser*, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 132. *Euglypha curvata*, *Perty*. *E. margaritacea*, *Wallich*. *Cyphoderia margaritacea*, *var. major*, *Penard*.

General and abundant. The largest specimens observed were equal in size to those described by *Penard* as *var. major*, and were obtained from Staveley Dam, near Knaresborough, W. Yorkshire. Length up to  $165\mu$ ; breadth  $66\mu$ . It was obtained at over 3000 ft. elevation on Snowdon, N. Wales.

The form with the prominent mamillate process at the fundus was noticed from Wicken Fen, Cambs., and from Lough Neagh, Ireland.

From Llyn Idwal, N. Wales, many active animals were noticed in which the body-protoplasm had retreated from the thick end of the shell, leaving a large space, but no strands of protoplasm stretched across this space from the body-protoplasm to the shell as in *Arcellas* and *Hyalosphenias*.

From Bowness, Westmoreland, numerous small specimens were observed with an apparently homogeneous, deep-brown shell, which was asperulate on its outer surface. The neck was also more pronounced and bent than in any other specimens I have seen. Length of shell  $81-87\mu$ ; breadth  $28-31\mu$ .

## Fam. GROMIINA.

Gen. PSEUDODIFFLUGIA, *Schlumberger*.

48. PSEUDODIFFLUGIA GRACILIS, *Schlumberger*, in *Ann. Sci. Nat.* 1845, iii. p. 254; *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 198, t. xxxiii. ff. 18-28.—*Pleurophrys sphaerica*, *Clap. et Lachm.* 1859. *Pleurophrys? amphitrematoides*, *Archer*.

Somewhat scarce and liable to be overlooked.

Capel Curig, N. Wales, amongst *Sphagnum*. Also near the outlet of Llyn Bochlwyd, N. Wales.

Gen. PAMPHAGUS, *Bailey*.

49. PAMPHAGUS HYALINUS, *Leidy*, *Freshw. Rhiz. N. Amer.* 1879, p. 194, t. xxxiii. ff. 13-17.—*Arcella? hyalina*, *Ehrenb.*

1838. *Gromia hyalina*, *Schlumberger*, 1845. *Lecythium hyalinum*, *Hertwig & Lesser*, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 177, t. iii. f. 8.

Not uncommon in ponds and lakes. Observed most abundantly from ponds, Cirencester, Gloucestershire, among *Potamogetons*. Also abundant among *Isoëtes*, Llyn Idwal, N. Wales. Diam. 32–38  $\mu$ .

50. *PAMPHAGUS CURVUS*, *Leidy*, l. c. p. 196, t. xxxiii. ff. 11, 12.

The specimens were obtained from amongst mosses on wet rocks at over 3000 ft. elevation on Snowdon, N. Wales. They agreed very well with the animals described by Leidy, but were somewhat larger. Length 59–76  $\mu$ ; greatest breadth 32–36  $\mu$ . (Pl. 29. fig. 27.)

The vertical aspect of the animal was circular, and the pseudopodia, which were much branched, exhibited somewhat active movements. The animals were all feeding upon a small species of *Nitzschia*, individuals being observed in which the whole body, inside the thin, hyaline shell, was packed with the valves of this Diatom.

#### Gen. GROMIA, *Dujardin*.

51. *GROMIA STAGNALIS*, sp. n. (Pl. 29. fig. 28.)

Body small, perfectly spherical, usually green in colour. Shell chitinous, spherical, colourless or straw-coloured, very thin and transparent, smooth on its external surface. Mouth small, not readily visible. A large amount of protoplasm is exuded from the mouth, flowing all over the exterior of the shell, and giving rise to numerous, divergent and anastomosing pseudopodia. Nucleus small, often not visible, situated in the region away from the mouth.

Diameter of body 28–32  $\mu$ .

Among *Lemna minor* in stagnant ditches, near Brigg, Lincolnshire.

This beautiful Rhizopod occurred in abundance in the sediment collected by washing and squeezing *Lemna minor* and a few species of filamentous algæ. The only other freshwater species of *Gromia* are *G. fluviatilis*, *Dujardin* (in *Ann. Sci. Nat. sér. 2*, tom. viii., Zool. pp. 310–313), and *G. terricola*, *Leidy* (in *Proc. Acad. Nat. Sci. Philad.* 1874, p. 88; *Freshw. Rhiz. N. Amer.* 1879, p. 277, t. xlvii. ff. 1–4). From both of these species *G. stagnalis* is readily distinguished by its small size, green

colour, and habit. *G. fluviatilis*, Duj., was found among *Potamogeton* in the R. Seine, and has an oval shell of much larger size. *G. terricola*, Leidy, occurs on the ground amongst moist mosses, and is also a much larger animal.

A species found amongst *Ceratophyllum* and other water-plants, and described as *G. granulata* by Schulze (in *Archiv für mikr. Anat.* 1875, xi. p. 117, t. vi. ff. 5, 6), appears to me to be hardly distinguishable from *G. fluviatilis*, Duj.

The green colour of *G. stagnalis* is due to the presence of more or less diffuse chlorophyll in the protoplasm of the body. This has most likely been acquired by the animal whilst feeding on the numerous small green algæ with which it was associated. The protoplasm, which is poured out from the mouth of the shell in quantity, has a dull and somewhat translucent appearance, and exhibits no visible granulation. Nor is a continuous streaming movement to be observed in the pseudopodia, the general movements of which are very slow.

#### Fam. AMPHISTOMINA.

##### Gen. DIPLOPHRYS, Barker.

52. *DIPLOPHRYS ARCHERII*, Barker, in *Qu. Jour. Micr. Sci.* 1868, p. 123; *Hertwig & Lesser*, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 139, t. iii. f. 9.

In stagnant ditches, near Brigg, Lincolnshire. In bog-pools, Thursley Common, Surrey. Lough Gatny, Co. Donegal, Ireland.

All the specimens observed were small in size, and without exception were solitary individuals. The average diameter of the body was 14  $\mu$ .

##### Gen. AMPHITREMA, Archer.

53. *AMPHITREMA WRIGHTIANUM*, Archer, in *Qu. Jour. Micr. Sci.* 1867, vii. p. 4; 1870, x. p. 122, t. xx. ff. 4, 5.

This is evidently a rare species of Rhizopod. I have only obtained it once, from Llyn Llydaw, Snowdon, N. Wales. Length of shell 60  $\mu$ ; diameter of shell 36  $\mu$ .

Some shells of an amphistomous Rhizopod were observed from near Recess, W. Ireland, which probably pertained to this genus. The shells were chitinous, yellow in colour, and each aperture was situated on a slight protuberance. No living animals of this form were observed.

## Order VAMPYRELLIDA.

## Gen. VAMPYRELLA, Cienkowski.

54. VAMPYRELLA LATERITIA, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 253, t. xlv. ff. 10-16.—*Amœba lateritia*, *Fresenius*, 1856-8. *Vampyrella Spirogyræ*, *Cienk. in Archiv für mikr. Anat.* i. 1865, p. 218, tt. xii-xiii. ff. 44-56; *Hertwig & Lesser, in Archiv für mikr. Anat.* 1874, x. Suppl. p. 61, t. ii. f. 2.

Near Brigg, Lincolnshire. Diameter of animal without pseudopodia  $23-32\ \mu$ ; diameter inclusive of long pseudopodia  $67-77\ \mu$ . (Pl. 29. figs. 29-31.)

The Heliozoön-like form was abundant in a ditch amongst *Lemna minor*. The body of the animal was rarely globular, generally being ellipsoidal or even oblong. Outside the bright red, pigmented mass was a zone of clear protoplasm from which radiated a number of delicate pseudopodia of considerable length. Between the bases of these delicate pseudopodia the clear zone also gave origin to a number of much shorter, thicker pseudopodia, which, although only capable of comparatively slow movements, were extended or retracted more quickly than the elongate, delicate, protoplasmic filaments.

I was sufficiently fortunate to observe several of these animals feeding on the cell-contents of a species of *Mougeotia*. They have frequently been described as feeding on *Spirogyra*, but I know of no recorded instance of a species of this genus attacking a filament of *Mougeotia*. The animal attached itself firmly to the lateral margin of one of the cells of the filament, and in a very short time the long, delicate pseudopodia were retracted. At the same time the clear, outer, protoplasmic zone was continually putting forth and retracting shorter and stouter pseudopodia. That portion of the animal which originally attached itself to the cell *very soon had perforated it*, a portion of the animal protoplasm passing into the cell and causing a violent, dancing movement of the granules of the vegetable protoplasm. Whilst this was happening the chromatophore of the *Mougeotia*-cell was observed to be disintegrating at a point immediately opposite the place of attachment of the animal. I watched this destruction go on for about two hours; it was accompanied by much violent movement on the part of the small granules of the protoplasm, but during that time only a portion of the

chromatophore and surrounding protoplasm of the vegetable cell had been absorbed by the *Vampyrella*.

It has been stated by some authors that *Vampyrella* does not perforate the cells of *Spirogyra* and other filamentous algae on which it feeds, but attacks them and devours their contents by breaking the filaments at the joints. It is possible that it does so sometimes, but Cienkowski's original observation of the perforation of the cells of *Spirogyra* by this animal is, however, amply confirmed by the attacks I observed *V. lateritia* to make on the cells of *Mougeotia*, a plant which breaks at the junction of the cells much more readily than *Spirogyra*.

55. *VAMPYRELLA PEDATA*, Klein; Blochmann, *Die mikros. Thierwelt des Süßwass.*, I. Protozoa, Hamburg, 1895, p. 22.—*Hyalodiscus rubicundus*, Hertwig & Lesser, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 49, t. ii. f. 5. *Plakopus ruber*, F. E. Schulze, in *Archiv für mikr. Anat.* 1875, xi. p. 348, t. xix. ff. 9-16.

In the lakes at Capel Curig, and in Llyn-y-cwm-ffynon, N. Wales. Diameter of encysted stage 53-67  $\mu$ .

The animals observed were subspherical or ovoidal in form, with the endoplasm filled with small granules of a bright red colour. They had previously been gorging themselves with food, as they were filled with large numbers of small Desmids, the contents of which had also become of the same red colour. I was at first inclined to regard them as forms of *Hyalodiscus rubicundus*, but I think there is no doubt that the form described and figured by Hertwig & Lesser is merely a stage of *Vampyrella pedata*. The red colour of the Welsh examples was identical with the red colour observed in *Vampyrella lateritia*.

## Class HELIOZOA.

### Order APHROTHORACA.

#### Gen. ACTINOPHRYS, Ehrenb.

56. *ACTINOPHRYS SOL*, Ehrenb. in *Abhand. Akad. Wiss. Berlin*, 1830, pp. 42 etc. t. ii. f. 4; *Infus.* 1838, p. 303, t. xxxi. f. vi; Wallich, in *Ann. Mag. Nat. Hist.* 1863, xi. p. 446, t. x. f. 4; Leidy, *Freshw. Rhiz. N. Amer.* 1879, p. 235, t. xl.—*Trichoda Sol, Müller. Actinophrys difformis, Ehrenb.*

General and abundant in still waters.

From Llyn Teyrn, N. Wales, several forms were noticed of a deep reddish-brown colour and which possessed rather fewer pseudopodia. It is quite possible they belonged to some other species of Rhizopod, but they were associated with normal forms of *A. Sol*. Diameter 26-27  $\mu$ .

Forma PICTA.—*Actinophrys picta*, Leidy, *l. c.* 1879, p. 241, t. xlv. f. 4.

Near Brigg, Lincolnshire. Variable in size, the smallest forms having a diameter of only 31  $\mu$ . Leidy's species *A. picta* seems to me to be merely a form of *A. Sol* containing a considerable amount of more or less diffused chlorophyll granules. The general structure of the body, especially in the foamy appearance of the protoplasm and the nature of the pseudopodia, is in both cases identical.

57. *ACTINOPHRYS SUBALPINA*, sp. n. (Pl. 30. fig. 36.)

Body subspherical, colourless, consisting of semitransparent, finely granulated protoplasm from which foamy vesicles are entirely absent. Nucleus single, large, finely granulated, generally prominent. Contractile vacuole single, prominently situated at one edge. Pseudopodia very long, straight, rigid, with a delicate central axis, twice or three times longer than the diameter of the body, very robust and gradually attenuated to a fine apex; containing numerous granules, but with perfectly smooth edges.

Diameter of body 42-61  $\mu$ ; length of pseudopodia 60-125  $\mu$ .

Associated with *Pamphagus curvus* amongst wet moss on dripping rocks, Snowdon, N. Wales, at 3000 ft. elevation.

This fine Heliozoön appears to be quite distinct from any form of *Actinophrys Sol* I have yet come across. The *body*, which is relatively small, has a totally different structure from that of *A. Sol*, the finely granular protoplasm being absolutely devoid of the foam-like vesicles which are characteristic of the latter species. The *pseudopodia* are also of a different type, being relatively longer and stouter, and distinctly though gradually attenuated to a very fine point; they possess smooth edges, but contain numerous scattered groups of minute granules. Running up the middle of each pseudopodium is a delicate thread-like axis which can frequently be traced down into the body of the animal. The *nucleus*, which in *A. Sol* is usually difficult of observation, is

in *A. subalpina* quite a prominent feature. It is subspherical, situated more or less in the centre of the body, and exhibits a delicately dotted appearance, probably due to numerous fine granules.

The *contractile vacuole* is relatively large and is situated at one side of the body. It commonly projects somewhat from the outer surface of the body, and but for this protuberance the animal presents an even edge all round.

The habitat of *A. subalpina* is somewhat remarkable, the animals occurring amongst mosses on the vertical face of dripping rocks, and also at a considerable elevation above sea-level. I have never yet found *A. Sol* except in still water.

The dumbbell-like form of the animal (which I figure to illustrate the species—Pl. 30. fig. 36) might be considered merely as a case of fission, or as one stage in the conjugation of a pair of individuals. When found it was in the stage figured. It was watched for some hours, and it ultimately separated into two individuals; but, as these individuals were normal and did not undergo any further changes so long as they were under observation, I am inclined to regard it merely as ordinary fission.

#### Gen. ACTINOSPHERIUM, Stein.

58. ACTINOSPHERIUM EICHHORNII, Stein, *Sitzungsb. böhm. Akad. Wiss.* 1857, p. 41; Hertwig & Lesser, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 176, t. v. f. 1; Leidy, *Freshw. Rhiz. N. Amer.* 1879, p. 259, t. xli.—Actinophrys Eichhornii, Ehrenb. 1840.

Widely distributed in still water, but not so abundant as *Actinophrys Sol*.

#### Order CHLAMYDOPHORA.

##### Gen. HELIOPHRYS, Greeff.

59. HELIOPHRYS VARIANS, nob.—*Heterophrys varians*, Schulze, in *Archiv für mikr. Anat.* 1874, x. p. 386, t. xxvi. ff. 2–5. *Heliophrys variabilis*, Greeff, *ibid.* 1875, xi. p. 28, ff. 20–23.

In ditches, near Brigg, Lincolnshire. Diameter of body 25  $\mu$ .

There can be little doubt that *Heterophrys varians*, Schulze, and *Heliophrys variabilis* are forms of the same animal. The general body of the animal has in each case the same structure,

and in each it is enveloped in a thick coat of apparently mucous material. This external envelope is very delicate, and in the specimens I observed was only rendered visible by small bacteria which adhered to its outer surface. The pseudopodia in the animals described by Schulze and Greeff are of the same type, and, moreover, this type is somewhat peculiar. Some, but not all, of the pseudopodia are branched, and to my mind this not only indicates a close affinity between the above-mentioned Heliozoa, but is quite sufficient to separate Greeff's *Heliophrys* from Archer's *Heterophrys*.

The specimens observed from Lincolnshire possessed one nucleus, and this was in a somewhat excentric position. No contractile vacuoles were observed, but I have no reason to believe that they were absent.

Gen. HETEROPHRYS, Archer.

60. HETEROPHRYS MYRIAPODA, Archer, in *Qu. Jour. Micr. Sci.* 1869, n. s. ix. p. 267, t. xvii. f. 4.

Llyn-y-cwm-ffynon, N. Wales. Diameter of body about 27  $\mu$ . The forms observed were somewhat small, but agreed in all respects with Archer's description and figure.

61. HETEROPHRYS RADIATA, sp. n. (Pl. 30. fig. 34.)

Body small, spherical, dark grey in colour, protoplasm densely filled with granules of variable size. Nucleus single, situated in an excentric position. No vacuoles observed. Outer coat of gelatinous material quite colourless, almost as thick as the diameter of the body, with a finely fimbriated outer surface. Pseudopodia numerous, long and delicate, with numerous scattered granules along their length.

Diameter of body 21  $\mu$ , with outer coat 53  $\mu$ ; length of pseudopodia about 43  $\mu$ .

Epping Forest, Essex, in ponds.

This species of *Heterophrys* is nearest the one described by Hertwig and Lesser (in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 215, t. v. f. 3) as *H. spinifera*; but it is distinguished from the latter by the larger body and the much less fimbriated outer covering. The pseudopodia are also much more numerous, and in proportion to the size of the body are considerably shorter.

From *H. myriapoda*, Archer, it is distinguished by its smaller



size, its more copious outer coat, and by its longer and more slender pseudopodia.

This pretty little animal was obtained in washings of *Myriophyllum* from some large ponds in Epping Forest. None of the individuals observed possessed any green colour, and I was unable to detect the presence of any vacuoles. The outer zone which envelops the body is very wide, perfectly colourless, and its outer surface exhibits an exceedingly delicate fimbriation, much more delicate than the fringing of the corresponding structure in *H. spinifera* or *H. myriapoda*. The pseudopodia are delicate strands of protoplasm, with numbers of relatively large granules scattered at intervals along their length.

The extraordinary fimbriated (or 'spinous') outer coat of *H. Pavesii*, Garbini (in *Zoolog. Anzeig.* xxi. no. 575, 1898, p. 668, cum fig. 2), is alone a sufficient distinction between it and *H. radiata*.

#### Gen. SPHÆRASTRUM, Greeff.

62. SPHÆRASTRUM FOCKEI, Archer, in *Qu. Jour. Micr. Sci.* xvi. 1876, p. 858.—Heterophrys Fockei, Archer, *l. c.* ix. 1869, p. 267. Sphærastrum conglobatum, Greeff, in *Archiv für mikr. Anat.* 1875, xi. p. 29, t. ii. ff. 24-26.

Llyn Teyrn, N. Wales, among *Sphagnum cuspidatum*.

All the animals observed were solitary and some of them of small size, but otherwise they were exactly like Archer's description and figure.

#### Gen. LITHOCOLLA, F. E. Schulze.

63. LITHOCOLLA GLOBOSA, F. E. Schulze, in *Archiv für mikr. Anat.* 1874, x. p. 389, t. xxvi. ff. 6-10; Schaudinn, '*Heliozoa*' in *Das Tierreich*, Berlin, 1896, p. 14.

Diameter of body  $23\ \mu$ ; length of pseudopodia about  $31\ \mu$ .

Capel Curig, N. Wales.

The pseudopodia were granulated, and the investing sand-grains of the body-protoplasm were small and compact. I can see no difference between this animal and *Elæorhantis cincta*, Greeff (1873), except in the granulation of the pseudopodia. Perhaps the two are identical, and, if so, Greeff's name will take precedence. This *Heliozoön* was described originally from the Baltic Sea, and has also been recorded from freshwaters in Germany.

## Order CHALAROTHORACA.

Gen. POMPHOLYXOPHRYS, *Archer*.

64. POMPHOLYXOPHRYS PUNICEA, *Archer*, in *Qu. Jour. Micr. Sci.* ix. 1869, p. 386, t. xvi. f. 45; x. 1870, p. 105, t. xvi. f. 4.—*Hyalolampe fenestrata*, *Greeff*, in *Archiv für mikr. Anat.* 1869, v. p. 501, t. xxvi. f. 37; *Hertwig & Lesser*, l. c. 1874, x. Suppl. p. 221.

Wicken Fen, Cambridge; abundant among *Chara hispida* and *Utricularia vulgaris*, in peaty pools and ditches. Diameter of body about  $44\ \mu$ . Pseudopodia few, radiating, and without granules. All the animals exhibited a rather quick gliding motion through the water. The body-protoplasm contained a peculiar red pigment and sometimes a small amount of chlorophyll, the latter perhaps obtained in the food. The globules of the enveloping skeleton were from  $2\text{--}3.8\ \mu$  in diameter.

Hampsfell, Lancashire; scarce among *Myriophyllum* in pools. The examples were inactive and possessed few pseudopodia. Several large vacuoles were observed in one individual. The siliceous globules were  $3.2\text{--}4\ \mu$  in diameter.

N. Wales:—Among *Sphagnum* in a pool near Llyn Teyrn, Snowdon; Moel Siabod; Capel Curig; Glyder Fach, abundant in pools at 2200 ft.

Gen. RHAPHIDIOPHRYS, *Archer*.

65. RHAPHIDIOPHRYS PALLIDA, *F. E. Schulze*, in *Archiv für mikr. Anat.* 1874, x. p. 377, t. xxvi. f. 1.

Small forms with zoochlorellids; diameter of body about  $42\ \mu$ .

Llyn Idwal, N. Wales, among *Isoëtes*. (Pl. 30. fig. 35.)

Although the forms noticed from N. Wales possess chlorophyll-bodies, I think they should be referred rather to *R. pallida*, Schulze, than to *R. viridis*, Archer. All the examples seen were solitary, and they possessed several contractile vacuoles, two characters which distinguish the former species from the latter. Moreover, the outer coat was colourless and the pseudopodia were ornamented with granules as in *R. pallida*. Schulze, in his description of *R. pallida*, mentions some larger, pale, shining corpuscles in the body-protoplasm, corresponding in size and

position to the chlorophyll-bodies of *R. viridis*. The chlorophyll-bodies which I observed (zoochlorellids?) were numerous, but confined towards the periphery of the body. I think that the Welsh examples are best described as forms of *R. pallida*, Schulze, containing chlorophyll-bodies.

Gen. ACANTHOCYSTIS, Carter.

66. ACANTHOCYSTIS CHÆTOPHORA, Leidy, *Freshw. Rhiz. N. Amer.* 1879, p. 264, t. xliii. ff. 1-6.—*Trichoda chætophora*, Schrank, 1803. *Actinophrys viridis*, Ehrenb. 1833; *Infus.* 1838, p. 304, t. xxxi. f. vii. *Acanthocystis turfacea*, Carter, in *Ann. Mag. Nat. Hist.* 1864, xiii. p. 36, t. ii. f. 25; Hertwig & Lesser, in *Archiv für mikr. Anat.* 1874, x. Suppl. p. 204. *A. viridis*, Greeff, in *Archiv für mikr. Anat.* 1869, v. p. 481, t. xxvi. ff. 8-17. *A. pallida*, Greeff, *l. c.* p. 489, t. xxvii. f. 19.

A somewhat uncommon species, of which the two most interesting forms observed were the following:—

From Terrington, N. Yorkshire. A colourless form, with the smaller spines rather more numerous than the larger ones. Diameter of body  $74\ \mu$ ; length of large spines  $40-44\ \mu$ ; length of small spines  $16-19\ \mu$ .

From Barnes Common, Surrey. A specimen containing numerous oval chlorophyll-bodies and with the outer protoplasmic envelope of a brown colour. Only the delicate spines were observed and these were much longer than usual. Diameter of body  $67-76\ \mu$ ; length of spines  $38-54\ \mu$ .

67. ACANTHOCYSTIS PALUDOSA, sp. n. (Pl. 30. figs. 32, 33.)

Body spherical, consisting of finely granular protoplasm, often colourless, but sometimes bright green from the presence of numerous chlorophyll corpuscles of variable size. Nucleus central or subcentral, rarely visible in the living animal. Outer surface of the body firm, sometimes of a pale yellow colour, beset with very numerous short siliceous spines. Spines delicate, simple, irregularly radiating, and with pin-head-like bases. Pseudopodia comparatively scanty, long and extremely delicate, beset along their length with numerous fine granules.

Diameter of body without spines  $43-49\ \mu$ ; length of spines  $5.3-8\ \mu$ .

In ponds and ditches, Sheep's Green and Wicken Fen, Cambridgeshire. Near Shelf and near Ilkley, W. Yorkshire.

This animal is undoubtedly the same species as the

"*Acanthocystis*?" mentioned and figured by Leidy in his Rhizopods of N. Amer. p. 270, t. xliii. ff. 14-16. It is of the same size, the delicate spines are exactly similar, and the individuals were colourless or filled with bright green chlorophyll corpuscles. I have obtained it from four separate localities, and on two occasions it was in quantity; and as it has also been observed from the United States, and the specimens I observed showed no appreciable variation, I think it quite worthy to be named as a distinct animal. The same Heliozoön is mentioned by Scourfield (P. Z. S. 1897, pp. 786-789) as occurring from Spitsbergen.

To a certain extent it resembles the four following species:—*Acanthocystis flava*, Greeff, *A. aculeata*, Hertwig & Lesser, *A. Pertyana*, Archer, and *A. spinifera*, Greeff. *A. paludosa* is sufficiently distinct to need no differentiation from the first two species. From *A. Pertyana* and *A. spinifera* it differs wholly in the nature of the spines, which are much more numerous and delicate. The pseudopodia are few in number and granular in appearance as in *A. spinifera*, but the outer surface of the body to which the spines are attached seems to be very much firmer. *A. paludosa* also resembles *A. erinaceus*, Penard, 1889 (*cfr.* Schaudinn, 'Heliozoa' in Das Tierreich, 1896, p. 19), but is a larger species with relatively shorter and more numerous spines.

In old and dead individuals the spines readily become disengaged from the firm outer coat, and then each spine is seen to be pin-shaped, with a capitate base or point of attachment.

The living animal protrudes a few long delicate pseudopodia which can withstand considerable irritation before being retracted. When the pseudopodia are fully out, the animal glides slowly through the water.

### Order DESMOTHORACA.

#### Gen. CLATHRULINA, Cienkowski.

68. CLATHRULINA ELEGANS, Cienk. in *Archiv für mikr. Anat.* 1867, iii. p. 310, t. xviii.; Leidy, *Freshw. Rhiz. N. Amer.* 1879, p. 273, t. xlv.

Rare: among *Isoëtes* and numerous algæ, Llyn Ogwen, N. Wales. Pool near Windermere, Westmoreland. Also from the vicinity of Lough Neagh, Co. Armagh, Ireland; many of these specimens were attached in the encysted condition and had brown siliceous capsules.

## EXPLANATION OF THE PLATES.

c.v.=contractile vacuole.

n.=nucleus.

v.=vacuole.

## PLATE 28.

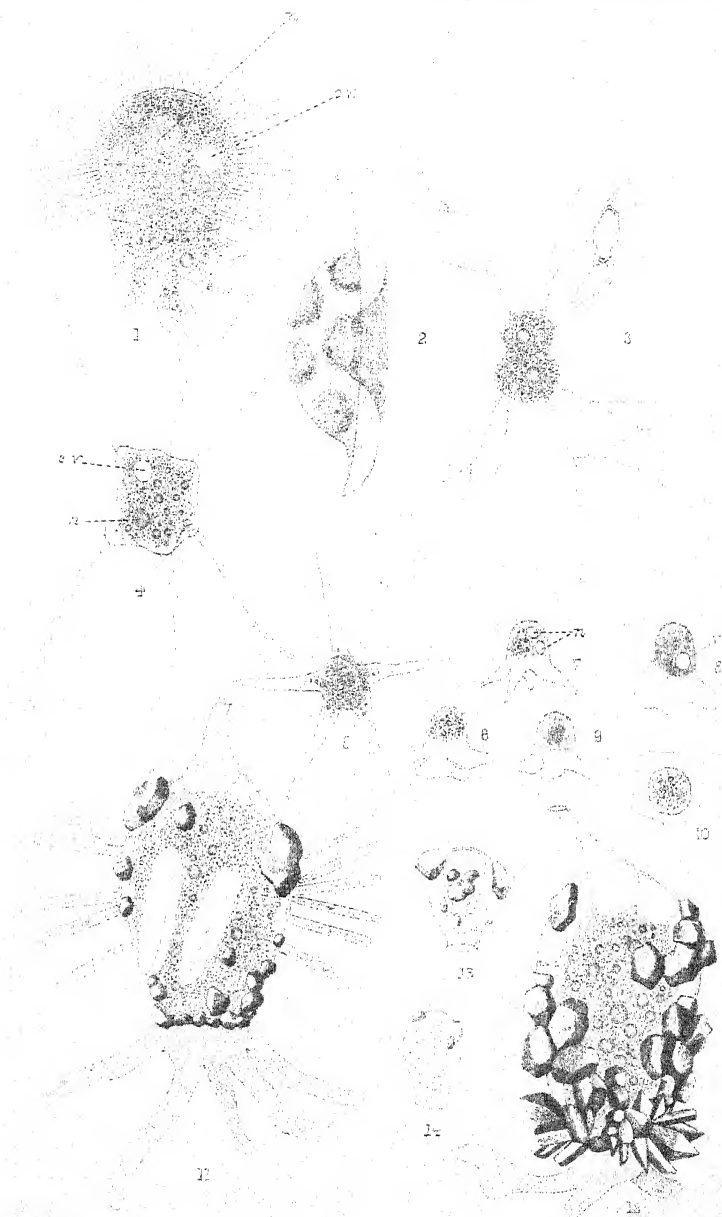
- Fig. 1. *Cochliopodium longispinum*, sp. n.  $\times 520$ . Active individual.  
 2. *Arcella artocrea*, Leidy.  $\times 150$ . Empty shell.  
 3. *Gymnophrys cometa*, Cienkowski.  $\times 520$ .  
 Figs. 4, 5. *Dactylosphaerium radiosum*, Blochmann.  $\times 520$ .  
 6-10. *Cochliopodium minutum*, sp. n.  $\times 520$ . Active individuals.  
 11, 12. *Diffugia acuminata*, Ehrenb., var. *elegans*, nob. Fig. 11 is a specimen from Wicken Fen, Cambs., with living Diatoms attached to the outside of the shell;  $\times 400$ . Fig. 12 is from Llyn-y-cwm-ffynon, N. Wales;  $\times 520$ .  
 13, 14. *Diffugia pyriformis*, Perty. Very small forms.  $\times 520$ .

## PLATE 29.

- Figs. 15, 16. *Centropyxis aculeata*, Stein. A form from Terrington, N. Yorks.;  $\times 170$ . Fig. 16 is a portion of the shell-membrane;  $\times 830$ .  
 17, 18. *Diffugia globulosa*, Dujardin. Very small forms.  $\times 520$ .  
 19, 20. *Quadrula irregularis*, Archer.  $\times 520$ .  
 21, 22. *Hyalosphenia cuneata*, Stein.  $\times 520$ .  
 23-26. *Leptochlamys ampullacea*, gen. et sp. n.  $\times 520$ .  
 Fig. 27. *Pamphagus curvus*, Leidy.  $\times 520$ .  
 28. *Gromia stagnalis*, sp. n.  $\times 520$ .  
 Figs. 29-31. *Vampyrella lateritia*, Leidy.  $\times 520$ . Fig. 29, individual with pseudopodia fully extended. Fig. 30, an example just attacking a filament of *Mougeotia*. Fig. 31, a third example which has perforated a cell of *Mougeotia* and partially absorbed the cell-contents.

## PLATE 30.

- Figs. 32, 33. *Acanthocystis paludosa*, sp. n.  $\times 520$ . Fig. 32, active individual of a bright green colour. Fig. 33 is a colourless individual with little protoplasm and a well-marked nucleus.  
 Fig. 34. *Heterophrys radiata*, sp. n.  $\times 520$ .  
 35. *Rhaphidophrys pallida*, F. E. Schulze.  $\times 520$ . Individual containing chlorophyll-bodies.  
 36. *Actinophrys subalpina*, sp. n.  $\times 520$ . Individual undergoing division, the nucleus having completely divided.
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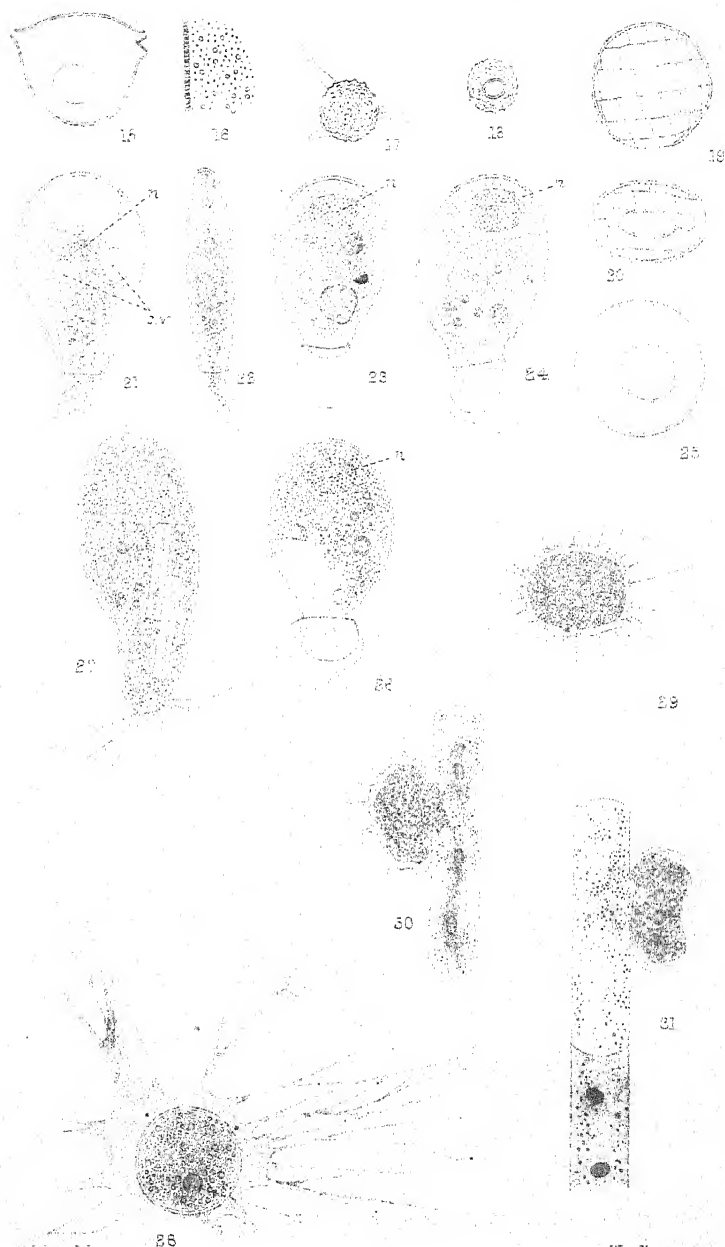


G.S. West del.  
A. R. Hammond lith.

West, Newman imp.

BRITISH FRESHWATER RHIZOPODA



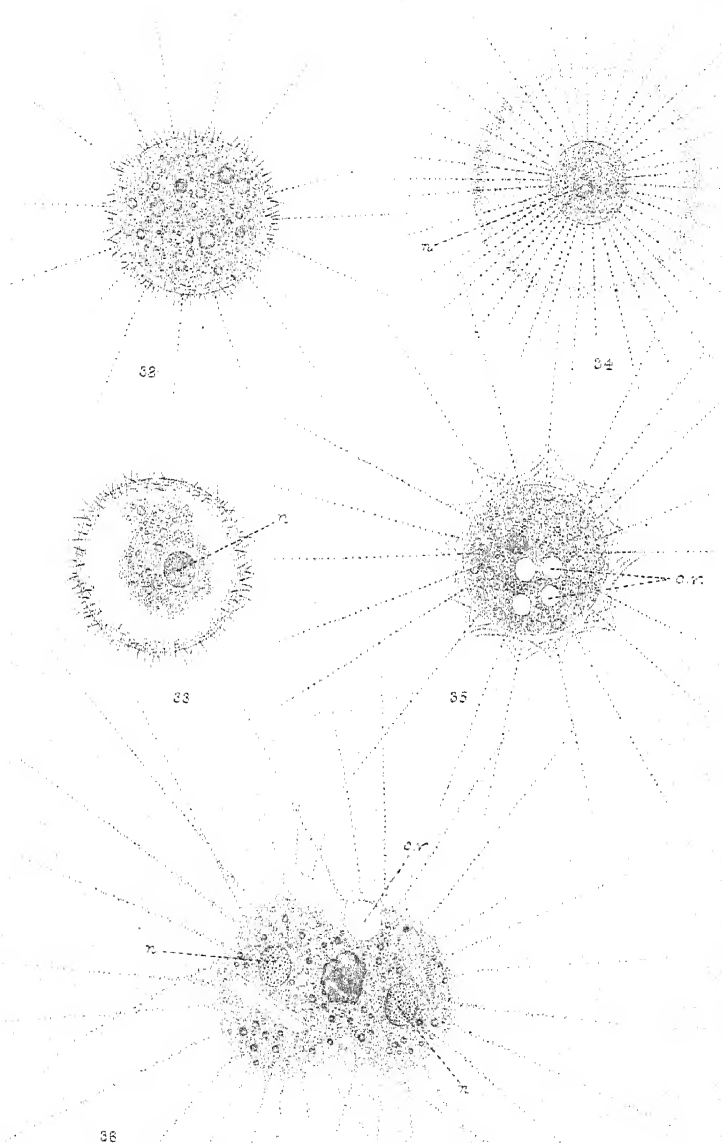


West, Newman imp.  
Am. Diamond lith.

West, Newman imp.



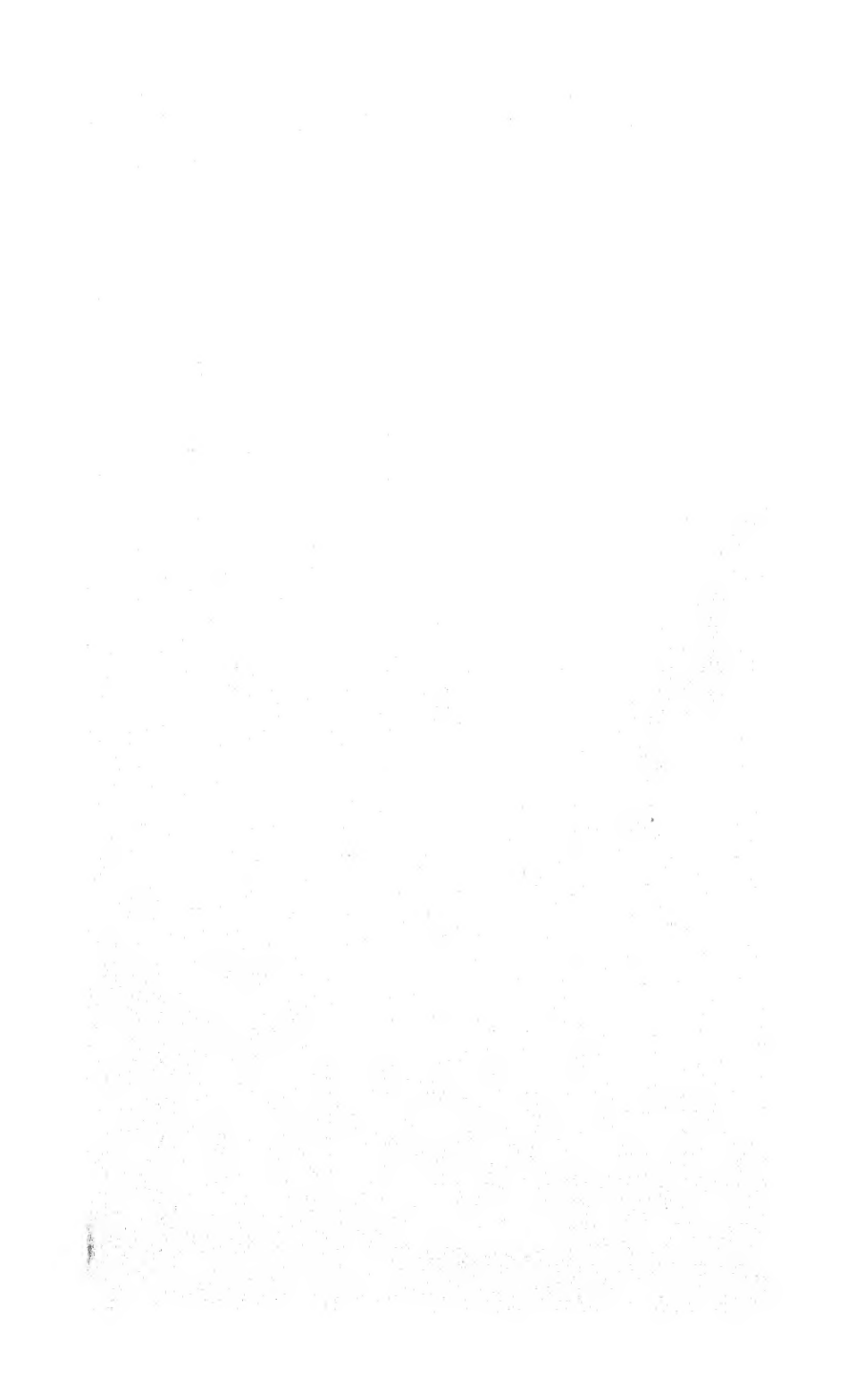




CSWest del.  
ARHammond lith.

West, Newman imp.

BRITISH FRESHWATER RHIZOPODA.



Some Points in the Morphology of the Palate of the  
*Neognathæ*. By W. P. PYCRAFT, A.L.S., F.Z.S.

[Read 2nd May, 1901.]

(Plates 31 & 32.)

IN a recent memoir on the Struthious birds (Trans. Zool. Soc. 1900, vol. xv.), I dealt at some considerable length with the arrangement of the bones of the palate, and instituted some comparisons between this arrangement and that prevailing amongst the "Carinatae." In this same memoir I proposed to adopt the characters of the palatal bones as a more convenient and more exact distinguishing feature than the characters of the sternum, which have done duty ever since their introduction by Merrem in 1813. In accordance with the characters of the palate, the Tinamous are to be divorced from the "Carinatae" with which they are generally associated, and placed with the Struthious birds. The Struthious birds and Tinamous constitute a group by themselves—the Palæognathæ; whilst the remaining forms made up a second group—the Neognathæ.

The contention that the Struthious (Palæognathine) palate is of a more ancient type than the Neognathine is admitted by all. The typical Palæognathine palate is that of *Dromæus*; and as this is to serve as a standard of comparison with the palatal bones now to be discussed, we may briefly enumerate its salient features.

The vomer (Pl. 31. fig. 1) is of great size, flattened dorso-ventrally, extending far forwards as a broad, median, grooved plate to beyond the middle of the beak; and backwards, to terminate in a pair of rami beneath the pterygoids, with which they ultimately fuse. The palatines are comparatively short, flattened, and slightly twisted bones. They run forwards, tapering as they go, to terminate in a slender rod, closely approximated to the mesial border of the very large maxillo-palatine process: they extend backwards to the level of the orbital process of the quadrate. The proximal half of the palatine (*pa.*) is relatively broad, and its mesial border is applied to the outer border of the fused vomero-ptyergoid bar.

To this vomero-ptyergoid bar and its relation to the palatine, attention is now specially directed. At the same time, it would be well also to carefully examine the form of the palatines and

their relation one to another, and to the maxillo-palatine process, in the accompanying figures.

In the palate of *Rhea* (Pl. 31. fig. 2) the vomer is relatively smaller than in *Dromæus*. It is deeply cleft anteriorly, thereby exposing the parasphenoidal rostrum, which is concealed in *Dromæus* when the skull is viewed ventrally, and posteriorly it terminates in a pair of broad "feet" closely approximated. Furthermore, the vomer is peculiar in that it is trough-shaped, the parasphenoid being received into the trough. The feet of the vomer, if further examined from the ventral aspect of the skull, will be found to be partly concealed by the palatines. Thus the primitive position of the palatines, which obtains in *Dromæus*, has in *Rhea* undergone a change. They have moved, from their original position *outside* the vomero-ptyergoid bar, *towards the middle line*, and in doing so have come to underlie this bar.

This movement of the palatines inwards, and their connection with the distal end of the pterygoid, has played a very important part in the evolution of the avian palate.

We may trace the early stages in this movement of the palatines in the skull of the Tinamous.

The palate of the Tinamous, as I have already pointed out, closely resembles that of *Rhea*. This close resemblance being undeniable, we need only concern ourselves here with the differences between the two skulls. The most important of these differences for the present connection are concerned with the vomer, palatine, and pterygoid.

The pterygoid, in the Tinamous, appears to be relatively longer than in *Rhea*. This appearance is deceptive, and is really due to the fact that the vomer and palatines have shifted considerably forwards, whereby the vomer terminates much further forward along the parasphenoidal rostrum—so much so, that the choanæ (which are narrower than in *Rhea*) lie almost entirely in front of, instead of almost entirely behind the ant-orbital plate (prefrontal), terminating immediately beneath the bony style (lachrymo-nasal pillar), taking the place of the maxillary process of the nasal. In other words, the choanæ extend forwards as far as the anterior limit of the lachrymo-nasal fossa.

The palatines of the Tinamous have become more rod-shaped.

Seen from the ventral aspect of the skull, the proximal end of each, instead of expanding into a broad plate to underlie the base of the vomer, and extending backwards in a spike-shaped fashion along the pterygoid to within a short distance of the basipterygoid process, as in *Rhea*,—on the contrary, cross the pterygo-vomerine bar obliquely, as a narrow flattened lamina, attached merely by its mesial border. The palatine of the Tinamou, then, is confined to the distal end of the pterygoid, instead of extending back to within a short distance of the basipterygoid process as in *Rhea*.

The vomer, as we have already remarked, has shifted relatively further forwards; it also appears to have undergone a slight relative reduction in size.

The most important features in all this are: (1) the forward shifting of the palatine to the distal end of the pterygoid; and (2) the inward shifting towards the middle line. Compare figs. 1-5, pl. 31. But it would be well to pause for a few moments to survey briefly one or two other features of the Tinamine palate before passing on.

Compared with that of *Rhea*, it will be remarked at once that in the Tinamous the maxillo-palatine processes have undergone a great reduction, though they are still of considerable size. In *Rhea*, these processes extend inwards and backwards, in the form of a pair of broad, plate-like, more or less fenestrated laminae. The postero-internal angle of the plate is continued backwards in the form of a long and delicate rod, closely approximated to the outer border of the palatine, and terminating beyond the middle of that bone. The great size of the maxillo-palatine process restricts the forward extension of the quadrato-jugal fossa to the level of the antorbital plate.

In the Tinamous the maxillo-palatine processes—though, as we have just remarked, of considerable size—are relatively much smaller than in *Rhea*. The backward extension (the palatine process) may be described as having the form of a narrow, concavo-convex band tapering to a point, and terminating at about the middle of the outer border of the palatine, which it supports as in *Rhea*. The furthest point of this maxillo-palatine process lies immediately behind and below the antorbital plate. This reduction of the maxillo-palatine process has extended the length of the quadrato-jugal fossa, which now

reaches as far forward as the anterior limit of the choanæ, and terminates immediately below the level of the anterior limit of the lachrymo-nasal fossa.

The anterior end of the palatine in *Rhea* is widely separated from the palatal process of the premaxilla, while in the Tinamous the anterior end of the palatine just touches the free end of the palatal process of this. This connection is brought about, partly by the forward shifting of the palatine, and partly by the narrowing of the beak, consequent upon the lateral reduction of the maxillo-palatine process.

We are now in a position to summarize the facts herein set down, and to select therefrom such as directly illustrate the transition from the Palæognathine to the Neognathine palate, which is the object of this paper.

The most primitive arrangement of the Avian palatal bones is to be found in the skull of *Dromæus*. The vomer is here of great size, terminating posteriorly in a pair of rami, continued directly backwards beneath, and fusing with, the pterygoids. *The palatines are connected, caudad, with the outer border of this vomero-ptyergoid bar, and are widely separated one from another.* Anteriorly the palatines are connected solely with the maxillo-palatine processes.

In *Rhea* the vomer is relatively smaller, and the paired extremities are closely approximated, but are continued backwards as in *Dromæus*, beneath the pterygoids. The palatines have shifted inwards, losing their original connection with the outer border of the vomero-ptyergoid bar, and, taking up a new position beneath this bar, have formed therewith a squamous suture. The approximation of the rami of the vomer towards the middle line has brought the distal end of the pterygoid into relation with the parasphenoidal rostrum. The distal extremity of the palatine is far removed from the palatal process of the premaxilla, and is connected wholly with the mesial border of the maxillo-palatine process.

In the Tinamous, the vomer is still relatively further reduced, and does not embrace the parasphenoidal rostrum so completely as in *Rhea*. The relations between vomer and pterygoid are much as in *Rhea*. The palatines bound the feet of the vomer externally, and will be found to be connected with the pterygoid by an oblique and scarcely perceptible suture. By the reduction in

the size of the maxillo-palatine processes, they begin to come into contact with the palatal process of the premaxilla: the one touching the other by the tip only. The shifting forward of the palatine and vomer is a feature of great importance, as thereby an approach is made towards the Neognathine palate. The approximation of the palatines to the palatal process of the premaxilla is another Neognathine feature.

Some confusion seems to exist, even now, as to the nature of the palate in the Struthious birds. Thus, in so recent and authoritative a work as the 'Dictionary of Birds' (article Skull) the palates of *Struthio*, *Apteryx*, and the *Crypturi* are said to be *Schizognathous*, whilst the palate of *Dromæus* is described as *Desmognathous*. Now Huxley, who introduced these terms, added yet another—*Dromæognathous*, for the special purpose of expressing the fact that the palate of certain "Carinate" birds—the *Crypturi*—was Struthious in type, and could not therefore be included amongst his *Schizognathous* forms.

The palate of the Palæognathæ might be described as *Desmognathous*; but certainly there are no members of this group in which it is *Schizognathous*. It would be better to adopt the term Huxley coined for the *Crypturi*—*Dromæognathous*. This form of palate is not *Desmognathous* in the sense in which Huxley used this term.

In the *Dromæognathous* palate the palatines never meet one another caudad, in the middle line, and never overlap the palatal process of the premaxilla anteriorly. The pterygoid is never segmented, and consequently is never free, but is immovably united with the vomer, vomer and palatines, or palatines only—as in *Struthio*.

We may now pass on to consider the peculiarities of the Neognathine palate, and the changes which it undergoes within this group. This, indeed, is the avowed purpose of the present contribution. At the same time, so far as is possible, we shall attempt to show how the Neognathine has arisen out of the older Palæognathine form.

The Neognathine form may be briefly characterized as that in which the palatines meet one another in the middle line, caudad. If, for working purposes, we confine our description to adult skulls, we might define the Neognathine skull, in all but a few cases to be dealt with presently, as that in which the



palatines meet one another in the middle line caudad, and support the vomer between them, whilst the pterygoids join the palatines not by suture, but by a true joint.

The Schizognathous skull of any adult Gull or Plover will admirably illustrate the differences between the Palæo- and Neognathæ. The changed form and relations of the palatines are here almost diagrammatically emphasized. Anteriorly, they are seen to be quite independent of the maxillo-palatine processes, passing below them, and forwards, to fuse with the palatine processes of the premaxillæ. Behind, they touch one another and join the long pterygoids by a joint. On both ventral and dorsal aspects strong keels have been developed. The inner ventral keels have grown downwards so as to enclose the vomer in a deep, cavern-like hollow. The vomer itself is seen to be held in position by the embrace of the mesial dorsal border of the palatines. In size it is now relatively greatly reduced, but has developed a strong blade-like keel \* passing backwards into a pair of rami attached to the dorsal border of the palatines as we have just indicated. The maxillo-palatine processes are not unlike those of the Tinamous, being shell-like scrolls of bone. They do not, however, extend so far backwards, afford support to the palatines, nor embrace the vomer. The pterygoids are long, rod-shaped, and articulate with the palatines by a true joint. Basipterygoid processes for the support of the pterygoids, caudad, have been dispensed with.

The pterygoid, in some Lari, is keeled dorsally; and this keel increases in height from before backwards, so that immediately behind the pterygo-palatine articulation it has attained a considerable height, rising to embrace the parasphenoidal rostrum on either side. It is possible that modifications in the form of the pterygoid, to be discussed presently, may be traceable to the excessive development of this terminal portion of the pterygoid keel.

The adult skull in the Neognathæ, it has just been remarked, differs from that of the Palæognathæ, amongst other things, in that the pterygoid is a free bone, articulating at the one end with the quadrate, at the other with the palatine.

This being so, it follows that the relations between the vomer

\* The vomer in many forms, e. g. *Cariama*, is represented only by a blade-like lamina; in others this is reduced to a mere spicule, e. g. some *Galli* whilst in many forms it is entirely wanting.

and pterygoid must be quite other than those which obtain in the Palæognathæ. A comparison of adult skulls will show that this is the case: that the palate in the two forms is quite different in this respect, the vomer in the Neognathous palate being supported by the palatines.

But the skull of the young bird throws quite a different light upon the nature of the relations between pterygoid, vomer, and palatine. Care must be taken, however, to select favourable types for study, specialization having, in the skulls of many forms, obliterated more or less completely the evidence for the facts which follow.

If the nestling skull, preferably of some Schizognathous form, such as of the *Lari*, *Charadrii*, *Otidæ*, *Sphenisci*, or *Colymbi*, be examined, the pterygoid will be found to be continued forward into a sharp point, which either slightly overlaps or just touches the bifid end of the azygos vomer. That is to say, the right and left pterygoids are connected with the right and left limbs of an originally paired vomer—as in the Palæognathæ. The palatines, which, as we have already remarked, have moved inwards to meet one another in the middle line, underlie the distal ends of these pointed pterygoids. Immediately behind the palatines the pterygoids segment, the segmentation at first resembling a fracture, but later this fracture becomes transformed into a true joint. By this time the terminal ends of the segmented pterygoids have become perfectly ossified, and simultaneously have begun to effect a union with the underlying palatines, the distinction between pterygoid and palatine being marked by a fine suture. Eventually all trace of the suture disappears, and with it the evidence of the pterygo-vomerine connection. The existence of the distal end of this segmented pterygoid is entirely obliterated, so that there is nothing to show that this joint is not a true articulation between two distinct bones—pterygoid and palatine. In other words, there is no indication of the fact that this joint is formed by segmentation of the pterygoid, and the fusion of its segmented portion with the palatine to form a palato-pterygoid articulation. In some skulls the palatine extends backwards below the segmented portion of the pterygoid to join with it in forming the articulation (Pl. 32. fig. 2). This segmented portion of the pterygoid I have elsewhere called the hemipterygoid; it is the mesopterygoid of W. K. Parker.

This hemipterygoid varies greatly in its relative size in different groups. In some it has become so greatly reduced that it ceases to segment off from the main body, and remains as a kind of peg projecting from the antero-dorsal angle of the pterygoid trunk. This is the case in the Galli and Anseres. In these groups the vomer, when present, is therefore supported entirely by the palatines.

In the Falconidæ, amongst the Accipitres, again it has entirely disappeared, the support of the vomer being undertaken by the palatines.

As a consequence, then, of the inward movement of the palatines, the hemipterygoid element is slowly undergoing suppression. In some cases, as we have just remarked, only the merest vestige remains. In the majority of cases its connection with the vomer is but of the slightest. The support of this element has practically been transferred to the palatines.

The nature of this support is seen with almost diagrammatic clearness in the Penguins. Herein the palatines, caudad, are plate-shaped. The mesial border of each runs at first beneath the hemipterygoid, then beyond this upward and forward for a considerable distance. The whole of this region beyond the hemipterygoid is applied to the dorsal border of the vomer, which only just reaches back to the tip of the hemipterygoid.

Numerous stages in the decay of the disappearing hemipterygoid are to be found. The skull of an immature *Tetraptyryx paradisea* in the British Museum collection affords an admirable object-lesson in this degeneracy. Here (Pl. 32. fig. 4) the free end of the hemipterygoid fails to reach the vomer, which is now entirely supported by the palatine in the manner just described.

The vomer, like the hemipterygoid, is also in many cases completely suppressed.

Attention must now be directed to the palatal bones of certain Coraciomorphæ (*Gadow*).

Lack of suitable material (in the shape of embryos or nestlings) has greatly hampered me in the investigation of these groups; but enough has come to light to enable me to deal therewith in the present contribution. It is to be hoped that help in this matter will come to hand shortly. We should be very grateful at the Natural History Museum for ripe embryos and nestlings

to make up the blanks, which are many, in the collections. When this has been done, one or two very interesting points can be definitely settled.

The Cuculi and Psittaci may be dismissed in a few words. The former have the typical Neognathine palate; the pterygoid being segmented, and the hemipterygoid fusing with the palatines, and forming a joint with the main body of the pterygoid. The pterygoid in the Psittaci also forms a joint at its distal end, but nothing is yet known concerning the presence or absence of the hemipterygoid—we do not know whether it is present and fuses with the palatine, or has been lost by atrophy as in the Galli or Anseres. Certain of the Coraciiformes and Passeriformes afford us some interesting modifications of the type.

Briefly, these modifications seem to show that the forms in question differ from all the remaining Neognathæ in that the pterygoid does not segment, but is continued forward directly on to the vomer when present, as in Palæognathæ. That is to say, the hemipterygoid element has not been lost by atrophy, but remains permanently in connection with the main pterygoid body. Between this and the normal Neognathine type are many gradations. The most extreme forms of this modification are perhaps to be found in the Capitonidæ and Bucconidæ.

In *Megalæma marshallorum*, one of the Capitonidæ (Pl. 32. fig. 7) the pterygoid is continued directly forward on to the vomer, terminating in a sharp point running obliquely over the dorsal border of its right and left limbs. This connection between the vomer and an unsegmented pterygoid is of course a Palæognathine character. Moreover, the palatine, as will be seen in the figure (*pa.*), is confined to the ventral border of the pterygoid, and in no way comes into relation with the vomer. It is significant, however, that in this skull the region of the pterygoid shaft that corresponds to the hemipterygoid is not a direct continuation of the shaft, but a curved plate rising somewhat suddenly from the distal end of the pterygoid shaft immediately above the free end of the palatine. This latter fits into the curved hemipterygoid border and abuts against the antero-ventral extremity of the pterygoid (fig. 7). On this account, from the ventral aspect of the skull, the pterygo-palatine connection appears to be by means of a joint, as in all the other Neognathæ. This joint is

continued upwards and forwards beneath the hemipterygoid for some distance. All this seems to imply that this unsegmented pterygoid is really not a primitive but a secondary character—an approximation to the original type.

The suggestion that the unsegmented pterygoid of the species described above is a secondary and not a primitive character, is confirmed by what obtains in *Cyanops asiatica*. Here the form of the pterygoid, its hemipterygoid plate, and its relations to the vomer, are precisely similar to what obtains in *M. marshallorum*, but the hemipterygoid is cut off from the main shaft, and fuses by its distal end with the palatine. Except that the fusion of the hemipterygoid with the palatine is not so complete as usual, this is a perfectly normal Neognathine palate.

There is one particular, however, in which the hemipterygoids of these two species differs from the normal type, and that is their relatively greater size and close approximation to the parasphenoidal rostrum, which is held by them in close embrace.

Another well-marked type of palatal modification is afforded by the Passeriformes. Foreshadowings of this occur in the Pici, and many modifications thereof occur amongst the Passeriformes. The evolution of these modifications I propose to deal with in a further contribution to this subject, wherein the morphology of the palate in the whole of the Coraciomorphæ will be, as completely as possible, set forth.

In this Passerine type, which has perhaps reached the high-water mark of specialization in the Corvidæ, the hemipterygoid (Pl. 32. fig. 6) is split off, not by transverse fracture, but by a very oblique segmentation extending from the ventral border of the distal end of the shaft forwards and upwards. The vomer is in contact with the distal end of this reduced hemipterygoid. The main shaft of the pterygoid, immediately behind the hemipterygoid, expands into a slipper-shaped plate, which is closely applied to the parasphenoidal rostrum on either side. The palatines run along beneath the hemipterygoid, but instead of terminating at the proximal end of this segment, run backwards to articulate with so much of the ventral border of the distal end of the shaft of the pterygoid as is applied to the parasphenoidal rostrum. From the ventral aspect of the skull the proximal ends of the palatines appear to lie in a groove hollowed out of the ventral border of the parasphenoidal pterygoid plate.

The peculiarly modified distal extremity of the free pterygoid the adult skull and the connection of this extremity with the fused hemipterygoid and palatine are features of great interest. The resultant oblique joint appears to be one which allows of but little motion. A comparison of the figures will make the peculiarities of this palate easier to understand.

It has been suggested (p. 348) that the dorsal keel of the pterygoid in the Lari might have some significance. We would remark here that it is possibly by the segmentation of a strongly keeled pterygoid that the large plate-like hemipterygoid of such forms as *Megalama*, for instance, may have been derived. Later on in development the keel of the shaft of the pterygoid may have been lost.

Before closing this paper, I would draw attention to the modifications of the pterygoid in certain of the Caprimulgi.

*Steatornis* affords a most perfect illustration of the segmentation of the pterygoid. In a nestling in the Museum Collection, this bone (Pl. 32. fig. 5) is continued forward as an unbroken and completely ossified rod to terminate in a sharp point above a vestigial vomer. The palatines have met together mesially beneath these pointed pterygoid extremities, which as yet remain one with the main shaft. In the adult (fig. 5 *a*) segmentation has taken place, not immediately behind, but some distance distad of, the extreme posterior ends of the palatines. The hemipterygoid fusing with the palatine, an oblique palato-pterygoid joint is formed (*cf.* fig. 5 *b*).

The other Caprimulgine forms to which allusion has been made are mentioned here, not on account of the hemipterygoid, about which I can at present say nothing, but because of the peculiar modification which the palato-pterygoid articulation undergoes.

In *Caprimulgus europæus* the pterygo-palatine articulation is a perfectly normal (Neognathine) one; the pterygoid shaft articulating by a joint with the extremity of the palatine. In *Eurostopus nigripennis* the pterygoid articulation is as in *Caprimulgus*, but the palatines send backwards on to the pterygoids two minute processes, one on either side. In *Nyctibius* this backward extension of the palatines has encroached still further upon the pterygoids so as to underfloor these for a considerable extent, thus entirely masking the nature of the pterygo-palatine articulation from the ventral aspect of the palate.

In *Podargus humeralis* the pterygo-palatine articulation is so oblique, that at first the pterygoid appears to be an unsegmented bone as in the Palæognathæ.

The peculiar form of the pterygoid in *Podargus* at first much disconcerted me, seeming, as it did, to show that the unsegmented, pointed, pterygoid was not alone peculiar to the Palæognathæ. A more careful study, however, has placed its real nature beyond all possibility of doubt—it has modified a cup-shaped articular surface into an elongated facet. The palatines in *Podargus*, as in *Steatornis*, are peculiar in that they send inwards a ventral keel to meet in the middle line, thus forming a tubular passage. In *Steatornis* the floor of this tube lies further forward than its roof, underlying the vomer. In *Podargus* the floor of the tube lies directly under its roof.

#### Summary.

Briefly, the result of this paper has been to show that the differences between the Palæo- and Neognathine palate are those of degree and not of kind.

The Palæognathine is undoubtedly the older form. In it the vomer and pterygoid are uninterruptedly connected, one with another, throughout life; whilst the palatines remain permanently separated one from another caudad, and are connected only with the maxillo-palatine processes distad.

In the Neognathæ the vomero-ptyergoid relations are interrupted by the segmentation of the pterygoid distally; whilst the palatines, caudad, have moved inwards to meet in the mid-ventral line beneath the distal ends of the pterygoids, with which they eventually fuse, and, distad, have lost their primitive connection with the maxillo-palatine processes, and have established a new connection with the palatine processes of the premaxilla. The fusion of the distal ends of the pterygoid with the underlying palatine is accompanied by segmentation of the former and the formation of a pterygo-palatine joint.

In my recent memoir on the Palæognathæ I inadvertently described the inward movement of the palatines as having resulted in "thrusting the vomer forwards" (p. 206). This is inexplicable, since it is obvious, from the very next sentence, that I had not lost sight of the fact that this bone still retains its primitive connection with the pterygoid. That both pterygoid

and vomer, however, have been affected by this movement there can be no doubt, since, as I have pointed out, in many cases it has brought about the suppression or atrophy of the hemipterygoid element, and has assumed the functions thereof by taking up the support of the vomer, as in the Anseres and Falconidæ.

The most primitive form of Avian palate is most certainly the Dromæognathous, *not*, as has been stated, the Schizognathous. The Schizognathous and Ægithognathous palates, are both specialized forms derived by modification of the Dromæognathous type. The Desmognathous palate is a highly specialized condition which appears to have arisen independently amongst both Schizo- and Ægithognathous forms.

The Neognathine palate is undoubtedly undergoing a further change, a change resulting in the transference of the support of the vomer from the pterygoid to the palatine. This has followed upon the movement of the palatines from the original position outside the pterygo-vomerine bar to a position beneath this. But the disturbance does not end here, for it is in the most highly specialized forms accompanied by the degeneration of the distal end of the pterygoid and the suppression of the vomer.

#### EXPLANATION OF THE PLATES.

##### PLATE 31.

Fig. 1. Ventral view of the skull of *Dromæus nova-hollandiæ*, showing the most primitive arrangement of the palatal bones among living birds. The vomer is of great size, and extends backwards in the form of a pair of broad limbs beneath the laminate, pointed pterygoid. The palatines are connected by suture, posteriorly with the external lateral vomero-ptyergoid border, anteriorly with the maxillo-palatine process.

Fig. 2. The palate of *Rhea americana*. The vomer has relatively decreased in size. Its relations with the pterygoid are much the same as in *Dromæus*; but this fact is masked by the palatines, which have moved inwards beneath the pterygo-vomerine articulation so as to approach one another in the middle line. The palatine, as in *Dromæus*, is connected by suture with the maxillo-palatine process anteriorly. It is interesting to note that the posterior narial aperture of *Rhea* has been largely filled up by the inward and backward extension of the maxillo-palatine process. In *Dromæus* this aperture is very large. The premaxillary processes of *Rhea* are also very large.

Fig. 3. The palate of *Nothoprocta perdicarius*. Compared with *Rhea*, it will be seen that the vomer is, relatively, still further reduced, and that the palatines have moved still further inwards beneath the



pterygo-omerine articulation. Distally, the palatines are seen to have come into relation with the maxillo-palatine processes, inasmuch as they just touch their hindmost extremity. The quadrato-jugal (inferior temporal) fossa has greatly increased in length.

Fig. 4. The palate of *Rissa tridactyla* showing the typical Neognathine palate. The inward movement of the palatines has reached its maximum, meeting one another in the middle line, beneath the pterygoid and vomer. Following upon this, the distal end of the pterygoid has become divorced from the main body, to form the hemipterygoid (fig. 1, Pl. 32). Later, the latter fuses with the palatine; and at the point of fracture, immediately caudad of the palatine, a joint is formed. Thus, in the adult Neognathæ by the disappearance of the hemipterygoid element the pterygoid appears to be a free bone, articulating with the palatine, instead of being connected therewith by squamous suture. The vomer in the adult skulls of this type appears now to be completely divorced from all association with the pterygoid.

Fig. 5. The palate of the Common Fowl (*Gallus bankiva* var. *domestica*). The bones in this palate have undergone still further specialization. The hemipterygoid appears to be totally suppressed, so that the vomer is actually supported only by the palatine (see also *Tetrapteryx*, fig. 4 a, Pl. 32). The slight groove indicated in the figure immediately caudad of the vomer was, in the freshly prepared skull, filled by two threads of cartilage running backwards from the vomer, and indicating its sometime further backward extension, wedged in between the palatines and articulating with the now suppressed hemipterygoid.

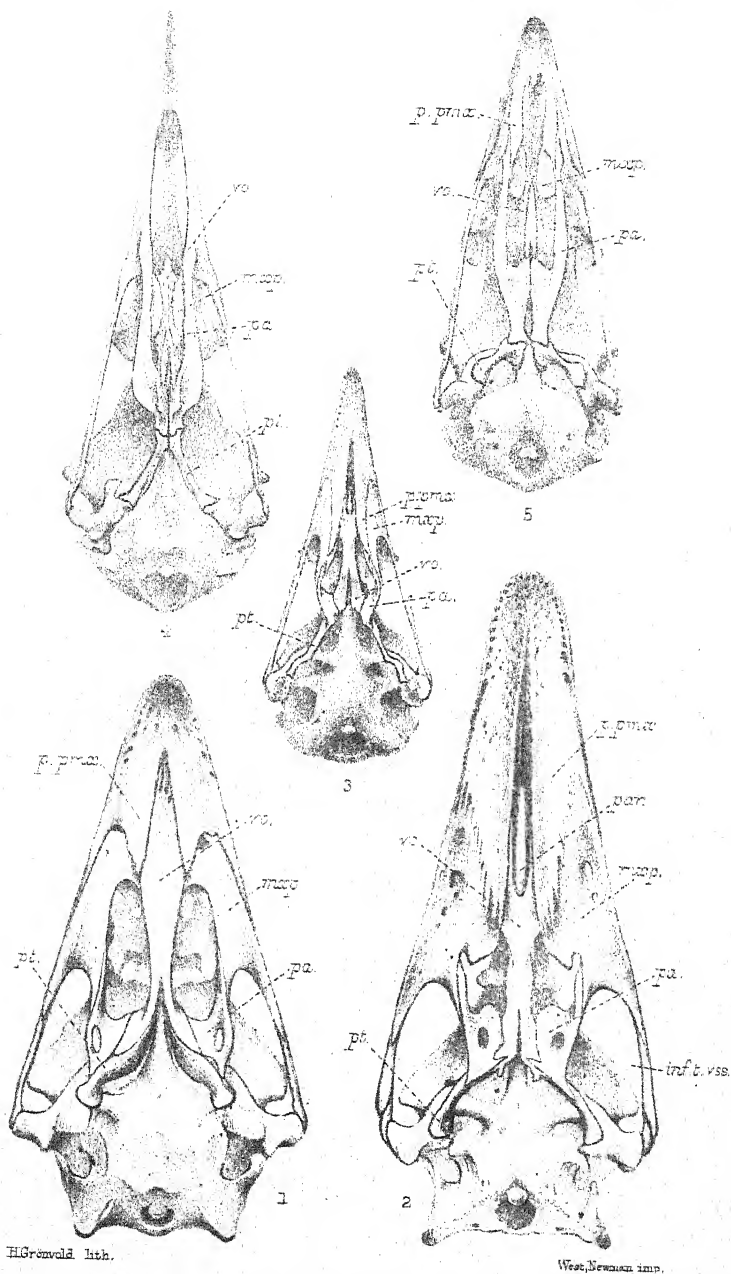
#### PLATE 32.

Fig. 1. The pterygoid of a nestling *Podiceps cristatus*, lateral view; showing the still distinct hemipterygoid element which extends forwards to the vomer. Later the hemipterygoid, losing itself by fusion with the palatine, gives the appearance, in the adult, of a true palato-ptyergoid articulation, thereby making it appear that the vomer in the Neognathæ is unconnected with the pterygoid, and thus, on this account, sharply distinguishing the Neo- from the Palæognathæ.

Fig. 2. The pterygoid of a nestling *Oceanodroma leucorhoa*, lateral view. The palatine has extended backwards beneath the hemipterygoid to share in the articulation with the main shaft of the pterygoid.

Fig. 3. The pterygoid of a nestling *Pygoscelis tenuata*, lateral view. At this stage the hemipterygoid appears as if wedged into the distal end of the main shaft, as by fracture; later a perfect glenoid cavity is developed between the distal end of main shaft and the hemipterygoid element.

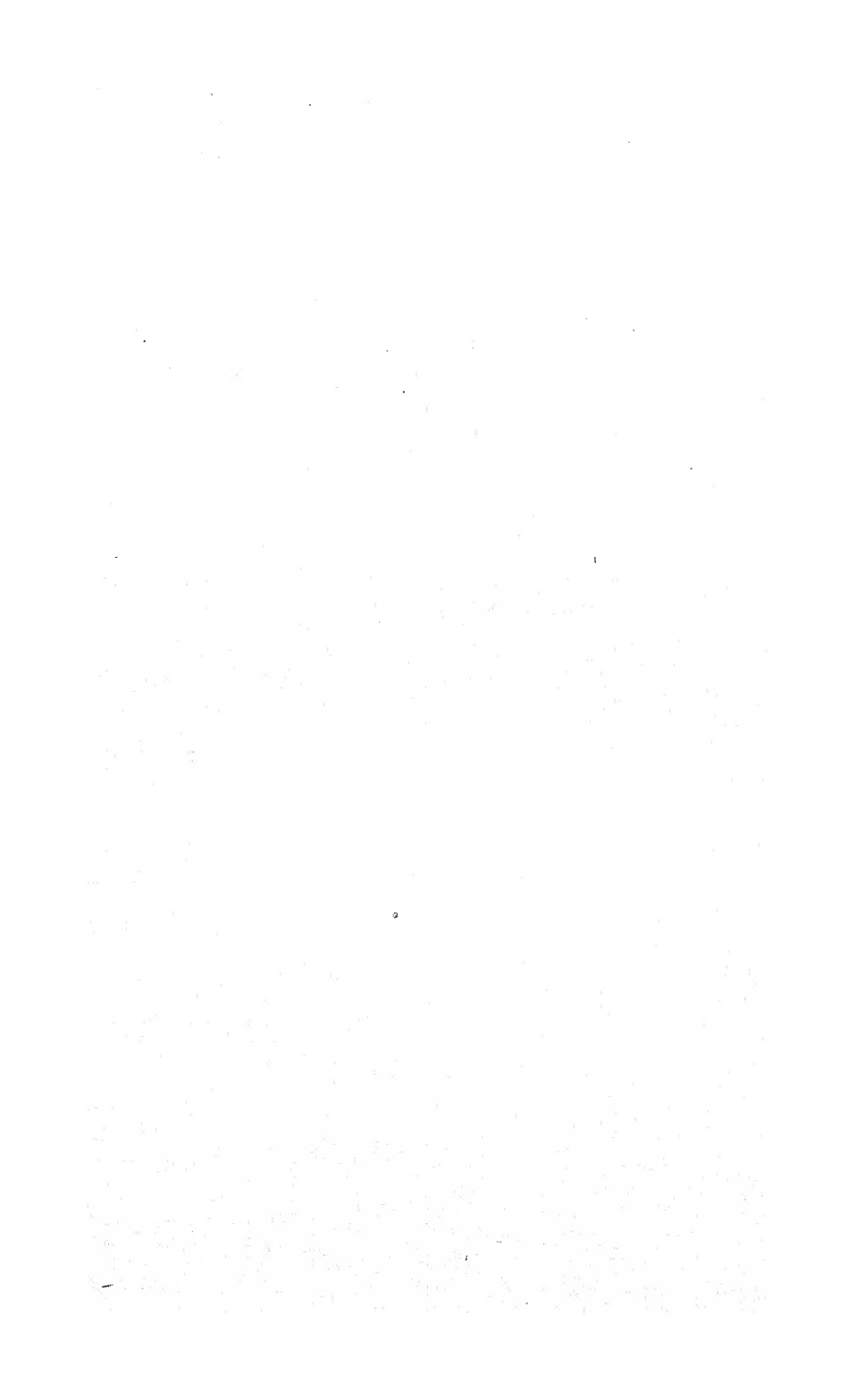
Fig. 3 a. The dorsal aspect of fig. 3, showing an early stage in the decline of the hemipterygoid, which just fails to reach the vomer.

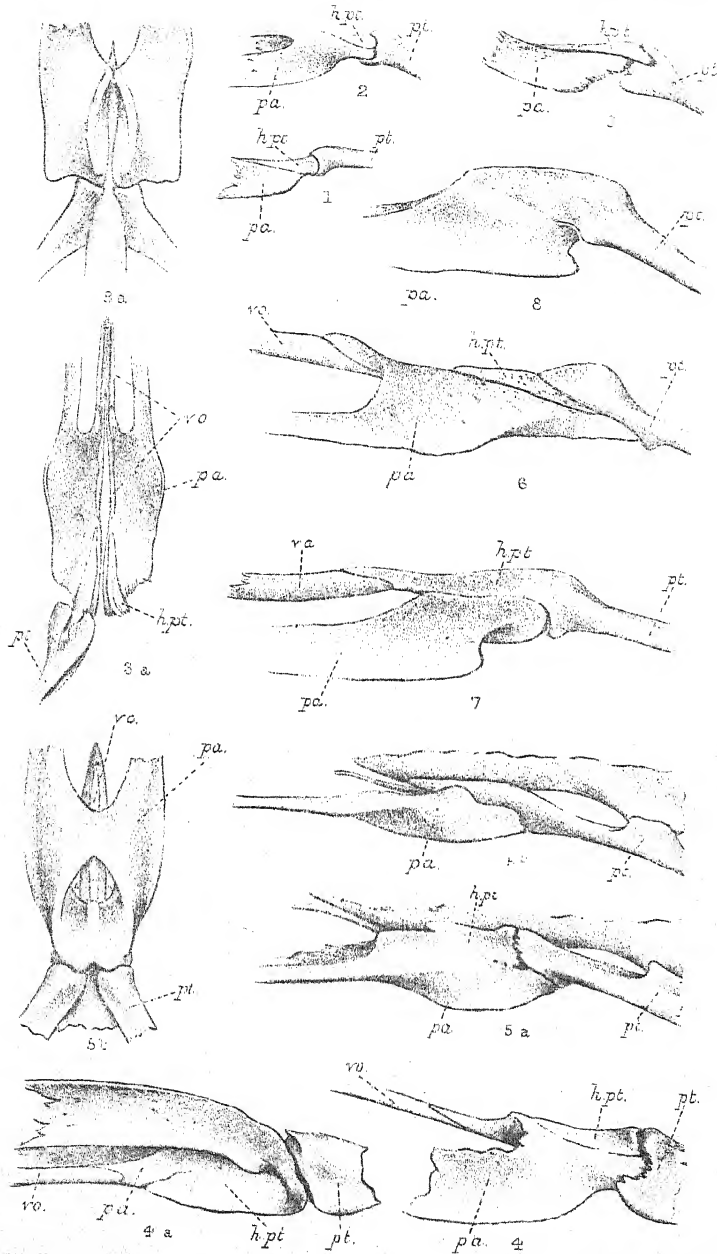


H. Grönwald lith.

West, Newman imp.

PALATE OF THE NEOGNATHE.





H. Grunwald del.

West, Newman imp.

PALATE OF THE NEOGNATHÆ.



- Fig. 4. Lateral view of the pterygoid of *Tetrapteryx paradisea*. The hemipterygoid and palatine bear the same relation to the main body of the pterygoid as in *Oceanodroma* (fig. 2).
- Fig. 4 a. In this figure, which represents the external lateral view of fig. 4, the hemipterygoid element is seen to be more degenerate than in *Pygoscelis* (fig. 3 a), and the vomer is in consequence supported entirely by the palatines.
- Fig. 5. Lateral view of the pterygoid of a nestling of *Steatornis caripensis*, wherein the hemipterygoid element has not yet segmented off from the main shaft.
- Fig. 5 a. The lateral view of the pterygoid of an adult *Steatornis caripensis*. The distal end of the pterygoid has now segmented off to form the hemipterygoid. It is connected with the main shaft by a sigmoid articulation, but remains traceable throughout life by reason of the fact that its distal end projects above the palatine.
- Fig. 5 b. Ventral aspect of fig. 5 a, showing the transverse articulation with the palatine and fused hemipterygoid element.
- Fig. 6. Lateral view of the pterygoid of the Rook (*Corvus frugilegus*). The hemipterygoid just reaches the vomer. Later, on its fusion with the palatine, the articulation with the main body of the pterygoid is oblique, not transverse as in the majority of Neognathæ.
- Fig. 7. Lateral view of the pterygoid of *Megalæma marshallorum*. Compared with fig. 6 it will be seen that in *Megalæma* the pterygoid has reverted to the original, Palæognathine, unsegmented condition, the hemipterygoid being continuous with the main shaft and extending forward to support the vomer, which is entirely free from the palatine.
- Fig. 8. Lateral view of the pterygoid of *Bucco Dysoni*. The pterygoid, as in fig. 7, is unsegmented. The vomer is vestigial or wanting. By further specialization the palatine has almost completely fused with the pterygoid, only a slight cleft marking the distinction between the two.
- Fig. 8 a. Ventral view of fig. 8, showing the last traces of an originally transverse palato-ptyergoid articulation.

## EXPLANATION OF LETTERS.

- h.pt.* = hemipterygoid.  
*inf.t.foss.* = inferior temporal fossa (quadrato-jugal fossa).  
*mx.p.* = maxillo-palatine process.  
*pa.* = palatine.  
*par.* = parasphenoidal rostrum.  
*p.p.mx.* = palatine process of premaxillary.  
*pt.* = pterygoid.  
*vo.* = vomer.

On the Corallum of *Turbinaria*. By S. PACE, F.Z.S. (Communicated by H. M. BERNARD, M.A., F.L.S.)

[Read 18th April, 1901.]

*The Formation of the Cup.*

No actual observations upon the early stages in the growth of the remarkable cup-shaped corallum of *Turbinaria* appear to have been yet recorded. It has usually been assumed that the parent polyp becomes submerged in the common cœnenchyma of the coral, and that its calicle is not recognizable after the corallum has attained the cup form. Thus Mr. H. M. Bernard, an admitted authority on this group, writes\*:—"A ring of buds shoots up round and from the sides of the parent polyp, together forming a cup, the wall of each bud rising up as a distinct cone above the level of the fusion of their walls to form the common cœnenchyma. The parent polyp dies away, and its primitive protuberant cone is immersed under the cœnenchyma formed from the fusion of the walls of a ring of daughters. These daughters carry on the colony, the budding of the daughters being limited to their free or outer sides, *i. e.* to the sides turned away from the axis of the cup." To illustrate his comparison with what occurs in the case of *Madrepora*, Mr. Bernard gives the two diagrams† which are copied in figs. 1 & 2. The supposed dying away of the parent polyp in *Turbinaria* was evidently assumed in order to explain the fact that it is so very unusual to find any trace of a calicle occupying a central position at the base of the cup.

An examination of younger growth-stages‡ than are contained in the British Museum collection, and the dissection of several small cups, have revealed the interesting fact that the parent polyp does not die away, but that it bends over to one side and takes part with its daughters in forming the rim of the cup. In a normal cup the parent calicle can always be traced as one, generally the largest, of the innermost ring of calicles.

\* Ann. Nat. Hist., ser. 6, vol. xx. (1897), pp. 131-2.

† Catal. Madrep. Corals Brit. Mus., vol. ii. London, 1896.

‡ The corals collected by me in Torres Straits I have presented to the British Museum.

The actual process is represented diagrammatically in figs. 3 to 10; and fig. 5 may be taken instead of Mr. Bernard's diagram

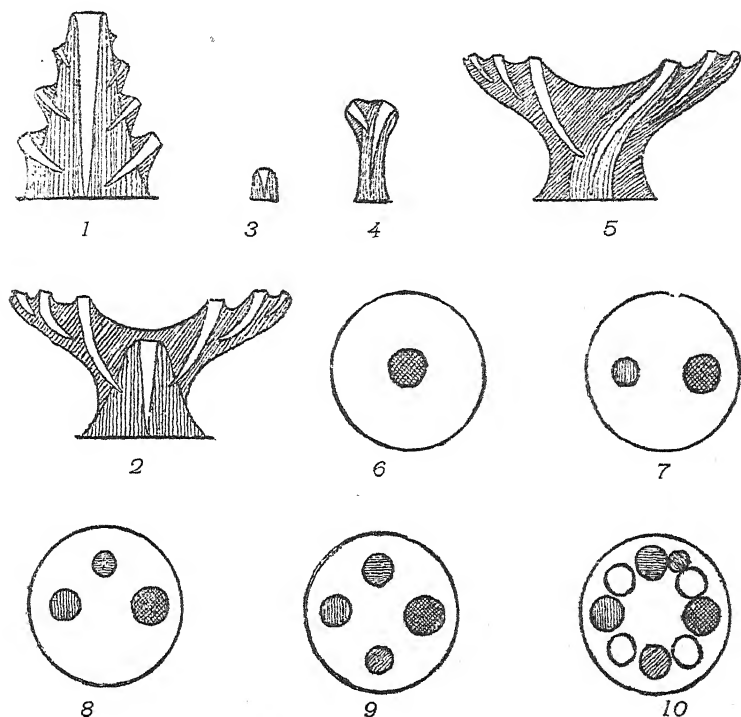


Fig. 1. Diagram of *Madrepora* showing the relationship of the parent calicle to the corallum, after Bernard.

Fig. 2. Erroneous diagram of *Turbinaria*, after Bernard.

Figs. 3-5. Diagrams illustrating the formation of a Turbinarian colony and the fate of the parent calicle.

[Figs. 1-5 are similarly shaded.]

Figs. 6-10. Diagrams of successive transverse sections of the stem of a young corallum to illustrate the mode of budding. The calicles are similarly shaded in each diagram.

(fig. 2) for comparison with that of *Madrepora* (fig. 1). It will be seen that the agreement between the two types is even closer than was suggested by Mr. Bernard; the only difference being that while in *Madrepora* the parent polyp retains its axial



position and grows up in advance of its daughters, so that it is at all stages the terminal polyp of the colony, in *Turbinaria* the parent polyp bends away from its first daughter-bud and then grows up together with and alongside its daughters, so that eventually it comes to form one of a ring of calicles of which its daughters are the other members.

While the central area of the cup is typically wholly cœnenchymatous, occasional examples are met with in which a calicle does occupy a central position within it; but, as already stated, this is a very unusual occurrence, and it would appear to be the result of a secondary torsion on the part of either the parent or of one of the daughter polyps. I have also noticed in a few specimens the existence of a slight central elevation which rather suggested that a calicle was buried at that point; but as no dissection was made, it may well be that the appearances observed were in reality due to the presence of some commensal or parasite.

#### *The Variation of the Corallum.*

A few words regarding some of the modifications which the Turbinarian cup undergoes with advancing age, and by the direct influence of its environment, may not be out of place, since I have had rather exceptional opportunities\* for the observation of corals and their habits, and since the so-called species of *Turbinaria* have been to so large an extent founded upon what are in reality but acquired characters. Bernard, in his Catalogue of the British Museum *Turbinariæ*, found himself obliged to group them according to the forms ultimately assumed by the cup; but, inasmuch as it was obvious that many of these might be adaptational or even accidental, he pointed out that his classification was purely morphological, and only to be regarded as a provisional one. It will now be my endeavour to show that the variations of a Turbinarian colony from the primitive cup-shape—the “crateriform” type of Bernard—*can* be readily explained by reference to the conditions under which the coral has

\* During a stay of nearly three years in Torres Straits, while engaged in the investigation of the commercial pearl-shell, some thousands of examples of *Turbinaria* in all growth-stages have passed through my hands or under my notice. Turbinarians are exceedingly plentiful on the reefs in this region, and young individuals, as well as large cups, are very commonly found on the backs of the pearl-shell collected by divers.

grown; though it by no means follows that heredity plays no part in determining the form of growth assumed by the corallum under any particular conditions, and it may well be that the *tendency* towards one type rather than another is inherited; this, however, can only be established by experiment.

As might be expected, the largest and most perfect cups are those formed at depths below the tidal zone, in clear water, and where the growth of the corallum is unrestricted by neighbouring objects\*.

Above extreme low-water mark there is a greater tendency for the coral to lose its cup-shape, and to become irregular by the folding and crumpling of its walls and by the adoption of an encrusting habit. Again, specimens are common on the reefs in which certain calices have budded to form secondary, more or less independent, colonies: subsidiary cups† may thus be formed within the parent cup, and some such individuals present a regularly "storied" appearance. In other cases the secondary colonies, instead of forming cups, take on an arborescent growth like that of a *Madrepora*. This modification‡, which I may term the "madreporiform" type, is a not uncommon one where the coral is growing at the bottom of a hole in the reef, and where growth in a vertical direction is of obvious advantage to the colony.

When a *Turbinaria* grows upon a shelf or ledge of rock it generally loses its cup-form; the side turned away from the free edge of the shelf ceases to grow, and the corallum thus becomes a more or less flattened, expanded plate§ overhanging the ledge.

When, during growth, the lower surface of the cup comes into contact with the substratum, irregular root-like outgrowths will

\* At the time of publication of the British Museum Catalogue the largest cup in that collection was stated (with a certain amount of pride) to measure as much as sixteen inches in diameter; such a specimen is, however, in reality quite a small one compared with the giants occurring on the shelling grounds in Torres Straits.

† These daughter cups, the result of proliferation of individual polyps, must not be confounded with the cup-shaped folds of the wall of the parent cup, which are of much more common occurrence.

‡ A very good example of this type of growth is figured by Ortmann as *T. maxima*—Zool. Jahrb., Syst. vol. iii. pl. vi. fig. 4.

§ The specimens of *T. reniformis* and *T. foliosa* figured by Bernard (Catalogue, pls. xvii. & xviii.) probably owe their form to this cause.

generally arise at the points of contact; and the specimen may thus acquire an appearance rather suggesting that of the Banyan tree with its numerous false stems. This type of growth has been described as *T. radicalis* by Bernard\*.

Not infrequently a cup becoming accidentally broken from its stalk continues to live in this detached condition; and, if it has at the same time been inverted, subsidiary cups will often be formed upon its upturned lower surface.

In addition to these modifications, due mainly to position, there are others which direct observation on the reef has enabled me to trace to another cause: namely, the danger of becoming silted up or clogged with the fine mud which is always a prominent feature on a coral-reef. This is apparently the greatest evil which a coral has to dread, and the structure of the corallum is frequently much modified in such a manner as to adapt it to life on muddy ground. Under such conditions the cup of a *Turbinaria* is often flattened out, the "peltate" type of Bernard, and the colony may even assume a convex form; or else the cup may be cleft on one side, or perforated at its base, so as to render it impossible for any silt to lodge within it.

Where the side of the original cup becomes cleft, one of the lobes thereby formed may extend round the outside of the cup, and, the growth of the other lobe being arrested, the corallum may take on a roughly spiral form, and silting will be obviated by the presence at the base of the corallum of a continuous gutter by which any foreign matter will be carried off. Those forms which Bernard has termed the "*Turbinariæ frondentes*" belong to this type of growth†. A very common method by which a Turbinarian defends itself against silt is that in which at an early stage the margin of the cup, or rather disc, becomes bent down at regular intervals or frilled‡, so that with further growth, the details of which are susceptible of various modifications, a very perfect gutter system results. In what

\* Brit. Mus. Catalogue, pl. ix.

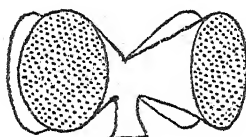
† The specimens of *T. auricularis* and *T. calicularis* figured by Mr. Bernard (Brit. Mus. Catal., pls. x. & xi.) are poor examples of this type. It is shown in its most perfect form by a specimen of *Montipora* (in which genus this modification is much more common than in *Turbinaria*) figured by Mr. Saville Kent in his 'Naturalist in Australia,' pl. xxiv. p. 146.

‡ The specimen of *T. peltata* figured by Mr. Bernard (Brit. Mus. Catal., pl. vi.) shows this very well.

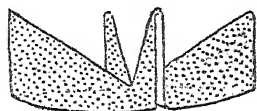
Mr. Bernard has termed the "bifrontal" type of growth, the elevated folds become greatly extended and their apposed lower surfaces fuse together all over: a corallum may thus arise which consists of numerous close-set vertical plates bearing polyps upon each of their faces and connected with each other by but a slight attachment at their bases. The narrow, more or less radial, interspaces of this type are practically open all round and so afford no lodgement for silt\*. In Bernard's "foliate" and "mesenteriform" types the elevated folds, instead of fusing together back to back, persist either as open frills, or, meeting, fuse only along the lines of junction. In this way a corallum consisting of a series of connected cylinders or cups, open at their bases, and bearing polyps alternately upon their inner and outer faces, may arise. By the suppression of the elevated folds a series of cups, each having, like the parent cup, an internal polyp-bearing surface, may be formed; while an exceedingly interesting extension of this type of growth is afforded by those cases in which the growth of the depressed folds has been arrested, so that the corallum has come to consist of a series of



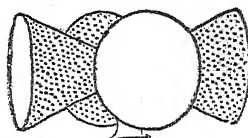
11



13



12



14

Figs. 11-14. Diagrams to show the origin of various types of growth by the folding of the margin of the primitive cup or disc. The polyp-bearing surfaces are dotted.

\* A series of specimens well illustrating this type is figured by Mr. Bernard as *T. gracilis*, Brit. Mus. Catal., pl. xxiii.

cups bearing polyps only upon their outer faces\*; in such an example any mud settling within the cup will of course not affect the polyps. The derivation of the above-mentioned types from the primitive cup or disc is illustrated very diagrammatically in figs. 11 to 14 (p. 363).

What Bernard has termed the "tabulate" type of growth is certainly, as he suggests, expressive of periodicity in the growth of the colony; and this periodicity appears to be often dependent upon the monsoons. The "set" of a current over a reef, and consequently also the "lay" of the silt, is in many places markedly different at these seasons; and, with every change in the direction of the drift, those parts of a coral which have been overwhelmed and killed by silt will tend to become again exposed, and may then take on a fresh lease of life, while the opposite face of the colony may in turn be buried until another change takes place in the set of the current. It is always possible to find some evidence of this periodicity on any large block of *Porites*, *Turbinaria*, &c., as it occurs on a reef; and, though of course many other factors besides the monsoons are concerned in effecting those changes which are continually taking place in the set of a marine current, yet such extremely regular alternations, as are expressed by the typically "tabulate" type of Turbinarian growth, can only be due to their succession.

The "glomerate" type, in which the corallum becomes enormously thickened to form the large hemispherical masses† so common on many reefs, would appear to be an adaptation mainly to withstand the battering of the surf and the rush of the tide over the reef. In many localities the strength of the current is so great that a corallum of any other form would most certainly be swept away; and on very exposed situations massive forms of *Turbinaria*, *Porites*, and such-like are the only corals met with.

\* A specimen referred to *T. magna*, Bern., in the Saville Kent collection in the British Museum from Shark's Bay, Western Australia, is a very perfect example of this type of growth, which is also to be seen in some parts of the specimens figured in the British Museum Catalogue, pls. xii., xiii., & xiv.

† Examples of these are contained in the Saville-Kent collection in the British Museum, and many such may be recognized in the beautiful collotype plates of coral-reefs which illustrate Saville Kent's 'Great Barrier-Reef.'

We thus see that many of those features which have been relied upon for the discrimination of "species" in this group are in reality but of secondary value; that, as with other corals, the characters of a *Turbinaria*, and more particularly the general form of the colony, are largely influenced by the conditions of its environment. On the other hand, *all* variation among Turbinarians (and the same is equally true of other genera) is certainly not the mere expression of adaptive modification. This is proved by the fact that specimens living side by side, and consequently under exactly the same conditions, so frequently exhibit quite obvious differences of type: such variation can only be genetic. I have myself observed, growing upon the same pearl-shell, three large Turbinarian cups which were quite typical examples of what must, in my opinion, be regarded as three distinct and well-marked species.

The question of defining the limits of a "species" is in no group such an easy one as it appears to the student who works only at the inadequate material represented in our museums\*; and, in the case of the corals, it is a problem of the greatest difficulty. At every turn the zoologist who studies Nature, not merely in the museum or laboratory, but also in the field, is confronted by facts such as those to which I have alluded,—facts which bring him once more face to face with that ever-recurring question, "What is a species?"—a question to which no satisfactory answer is as yet forthcoming; to which, indeed, no satisfactory answer can be looked for until such time as taxonomic research is placed upon a more truly scientific basis—until, in short, the zoological student has at his disposal large series of specimens and other data which have been collected with the express view of aiding the solution of those problems which are summed up in that familiar word "species."

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\* See a recent note in 'Nature' (vol. lxiii. pp. 490-1), in which the scientific collecting of zoological material is discussed.

The Life-history of the Black-Currant Gall-mite, *Eriophyes* (*Phytoptis*) *ribis*, Westwood. By CECIL WARBURTON, M.A., F.Z.S., Zoologist to the Royal Agricultural Society of England, and ALICE L. EMBLETON, B.Sc., 1851 Exhibition Science Research Scholar, Associate of the University of Wales (Cardiff College).

[Read 7th November, 1901.]

(PLATES 33 & 34.)

THE Black-Currant plant disease due to *Eriophyes ribis* first attracted attention in England in the year 1869, though the cause was not at first clearly ascertained. Since that time it has been the subject of frequent references by economic entomologists, who have generally recorded the fact that the pest was on the increase. To this day, however, our knowledge of the life-history of the mite is extremely limited, and the statements of various observers with regard to it are either too vague and general to be of much practical value, or are absolutely inconsistent and conflicting. No complete account of its life-cycle has yet been attempted, and its methods of distribution have remained a matter of conjecture.

The difficulty of the research is, of course, largely due to the minute size of the mite, which rarely exceeds one hundredth of an inch in length\*. To observe and record the condition of the mites inside the buds at various seasons of the year is a tolerably simple matter, but a thorough investigation of their habits involved watching the creatures throughout their wanderings, and here their small size proved a serious obstacle.

In a paper on "Insects affecting the Orange"†, H. G. Hulbard described certain phenomena with regard to an allied mite which suggested to him that it owed its distribution largely to the aid of various insects and arachnids, and it was the clue thus afforded by him that was immediately responsible for the observations on distribution in the present investigation.

\* The measurements are:—♀, length .23 mm., breadth .04 mm.

♂, " .16 " .03

† U.S. Dep. Agric. Ent. 1885.

*The Eriophyidæ.*

The Eriophyidæ (Phytoptidæ) or gall-mites are vermiform Acari, possessing only two pairs of legs, which have no claws, but are furnished with bristles and "feather-hairs" (Pl. 33. fig. 8; Pl. 34. figs. 10, 11). The elongated body is transversely striated, and terminates in a muscular disc-like organ (Pl. 33. fig. 9; Pl. 34. figs. 12, 13). It also presents certain bristles, of which the most important are a pair proceeding dorso-laterally from above the tail-disc.

About two hundred species of gall-mites have been described. They are all of small size, and are vegetable feeders, usually causing the abnormal growths known as galls on the leaves or stems of the plants they infest.

*The Black-Currant Disease.*

The disease is easily recognized by the presence, on infested bushes, of swollen and distorted buds, which, if still green, are found on examination to contain large numbers of the parasite. Badly attacked buds are entirely abortive, and eventually remain on the stems as brown dry knobs from which no leaves have arisen (Pl. 33. fig. 1). In milder cases of attack sufficient vigour is retained to give forth an enfeebled shoot (Pl. 33. fig. 2). As the hold of the disease upon the plant increases the effect becomes very striking. The failure of a large number of the buds forces into premature development the buds which would normally burst forth the following year, making overdrafts, so to speak, on the plant's vitality, and a stage is reached when it is no longer able to respond to the excessive calls made upon it. The provision for next year's foliage is already exhausted and the plant dies.

*Life-history of the Mite.*

The observations here recorded began on May 20, 1901, and were carried on without intermission until the middle of October. On May 20, of last year's mite-infested buds, those of which the growth had been entirely arrested were in some cases cracked, mites being visible externally in the fissures.

Individuals were also found wandering on the stems. Clearly the migration from the abortive buds had only recently commenced. Mites have been recorded by Newstead and others, as wandering on the plants much earlier in the spring. It is



probable that these early wanderers are nearly all doomed to destruction, but their presence is easily accounted for. Many of the infested buds are not too much injured to put forth leaves however weakly (Pl. 33. fig. 2); and if they succeed in doing this, the mites are deprived of their shelter and rendered homeless before the formation of next year's buds. This compulsory quitting of buds of which the mite has not succeeded in entirely destroying the germinating power may be regarded as more or less fortuitous, and is a very different matter from the definite migration which appears to take place from the wholly abortive buds.

As we have seen, this commenced, in 1901, about the middle of May. The activity of the mites attained its maximum about May 30, and practically ceased about the middle of June, by which time the arrested buds were dried up and destitute of living mites.

A very careful investigation of the behaviour of the mites during this migration period revealed some interesting habits which have hitherto escaped observation.

Three different methods of locomotion are employed by these creatures in their search after new feeding-grounds. These are: (1) crawling, (2) adherence to passing insects, and (3) leaping.

### *Crawling.*

The extremely anterior situation of the four short legs would seem to be ill-adapted for locomotion. Nevertheless the mite can crawl along quite actively, at the rate of three or four millimetres, or twelve to fifteen times its own length, a minute.

The motion of the legs is very scrambling and haphazard in appearance, but by wild exertion they drag the unwieldy body forward—an inert mass, trailing in the rear. When, however, the mite desires to change its direction, or to surmount an obstacle, the tail apparatus, with its muscular disc and bristles, comes into play. By this apparatus a hold is obtained upon the surface over which the mite is crawling, and the body is swung round, or the anterior portion is reared up and the obstacle surmounted. The tail-bristles are stronger and less wavy than they are represented in most figures of the mite, and appear to be accessory motile organs of no slight importance.

Their position in crawling may be seen in figs. 7, 20.

*Distribution by Insects.*

When the mites were first observed on the outside of the abortive buds, one curious point in their behaviour attracted attention, even under the slight magnification of a pocket-lens. Though some were actively crawling about, others appeared to be standing on end, and motionless, except for the waving of their legs. A series of observations and experiments were undertaken with a view to ascertaining the precise nature and purpose of this phenomenon, with the following results:—

A migrating mite, after crawling for a short distance in the manner already described, would obtain a firmer hold upon the surface of the bud with its tail-disc and assume an upright attitude (Pl. 33. figs. 5, 6, 9, Pl. 34. figs. 14, 15). The necessary hold was not always gained at the first attempt, the disc sometimes slipping, and here again the tail-bristles came into play, serving to anchor the animal to the bud and to give a certain amount of prop-like support to its rigid body. The position was not necessarily vertical, but at right angles to the supporting surface, and frequently oblique or even horizontal, and it was remarkable how the vermiform, soft-bodied mite would maintain for several minutes an attitude apparently so ill adapted to its structure. All the time its four short legs would be waving wildly in the air. A number of mites standing up in this way bore a remarkable resemblance to diminutive Hydras with greatly retracted tentacles.

After indulging in this performance for a period varying from one to five minutes, the mite would generally relax its rigid attitude, bring down its feet to the surface again, and continue its progress by crawling, only to resume its upright position and grotesque waving of legs a little farther on.

This behaviour was highly suggestive of a desire, on the part of the mite, to attach itself to any passing object, and its readiness to do so was easily proved in the most conclusive manner. If touched with a needle-point, it immediately let go its hold on the bud and was carried off on the needle. A camel's-hair brush or a feather applied to an infested bud was found to be swarming with mites on subsequent examination. In nature, the most likely carriers of the mites would, of course, be insects or arachnids. Accordingly spiders and insects of various kinds were either induced to run over infested buds, or examined after having been observed to come into contact with them spon-

taneously, and in almost every instance mites were found attached to their bodies or appendages. The fact was recorded of four different species of spider, of the larva of the currant-moth (*Abraxas grossulariata*), of the currant *Aphis*, of the larva of the two-spot ladybird (*Coccinella bipunctata*), of the black ant (*Lasius niger*), and of various other insects. So uniform was the result, that the investigation into the various creatures capable of distributing the mite was presently discontinued, as it was clear that almost any insect might perform that function, though those which wander widely and especially affect currant-bushes would necessarily be most efficient. It is probable that the currant *Aphis* is especially instrumental in spreading the disease. It crawls slowly along, feeling its way with its antennæ, to which the mites readily attach themselves, and the winged individuals would be extremely likely to convey the pest direct to another currant-bush.

#### *Method of Attachment.*

The mites do not seem in any true sense to grasp the objects presented to them, nor, indeed, do they possess any prehensile organ, unless the tail-disc may be placed in that category. Moreover, ordinary hairs and bristles are much too thick, relatively to the mites, for seizure by means of the jaws or legs.

Attachment always seems to take place, in the first instance, simply on account of some adhesive substance with which the bodies of the animals are coated.

A mite may be removed by any portion of its body being touched by the antenna of an aphid, but it quickly coils itself round the appendage in a worm-like fashion and brings its tail-disc into play.

Possibly the bristles and "feather-hairs" (Pl. 33. fig. 8) on the legs of the mite may to some degree entangle themselves among the fine hairs on the bodies and legs of insects. When removed on a camel's-hair brush the mites wriggle in and out among the hairs and soon secure a tolerably firm hold.

#### *Leaping.*

While the behaviour of the upright mites was under observation under the microscope, it was noticed that individuals sometimes disappeared from the field of view with a suddenness that made it impossible to see what precisely had happened. This

occurred several times before it was realized that the disappearance was not accidental, but that the animals were, in fact, leaping.

As soon as this was suspected, it was easy to verify it by concentrating attention on one individual and using powers which allowed the whole of its flight to be followed. The conclusions arrived at were these:—After several vain attempts to attach itself to a passing insect, a mite would cease to wave its legs, remain rigid a moment, and then launch itself forth, torpedo-like, into space. The precise mechanism by which this was effected could not be determined, but the terminal muscular disc, which had been observed to be retractile, was evidently the propelling organ. The tail-bristles were at first suspected of taking some part in the action, but further observation showed that, by retaining too firm a hold on the bud, they sometimes rendered the leap abortive, the mite simply falling backwards with considerable impetus instead of darting away. No great distance was covered by the leap, the longest measured being four millimetres, or about sixteen times the animal's length. When the mites leaped from a bud placed on a microscope-slide they alighted on their heads and fell over with the tail-disc most distant from the point of departure.

It was an interesting and suggestive fact that while the mites would remain upright with waving legs for several minutes in the still air of the laboratory, they could be induced to leap at once by blowing upon them with the breath or by means of a pipette. It would seem, then, that they first of all try to come in contact with a passing insect, and, failing this, take advantage of a puff of air to attain their object.

In view of the extremely doubtful advantage of a blind leap into space, the conjecture may be hazarded that the mite thus sometimes attains a flying insect which hovers near enough to fan it by the beating of its wings.

#### *Destination of the Migrating Mites.*

The problem of the immediate object of the mites in leaving the old buds by crawling, leaping, and adhering to insects next demanded a solution. At the height of the migration the new buds were already visible and beginning to swell, and the manner in which and the extent to which they acquired the disease had still to be ascertained. Moreover, the leap into space would

necessarily land many of the creatures on the ground, and it was conceivable that they sought or made some kind of shelter there from which a new attack sprang at a later period, or even that they sought the roots and set up there another form of the infestation. Finally, as it transpired that here and there a resting-bud which had begun to show after the conclusion of the migratory period contained the mites, it seemed possible that some might find a temporary shelter under the loose bark of the stem in the neighbourhood of such buds while still undeveloped. All these points were subject to careful investigation, the results of which may now be stated.

#### *Shelter under Bark.*

Unless called upon to furnish shoots on account of the extensive destruction of the ordinary buds by disease or injury, the resting-buds remain as almost invisible knobs under the bark of the stem. There is usually some loose bark in their vicinity and this was carefully searched for the mite, but with uniformly negative results. Specimens of a *Tyroglyphus* were found, and also some empty and longitudinally split shells which might have been hypopal casts, but of the gall-mite not a specimen.

#### *Behaviour on the Ground.*

To trace the actions of such minute creatures amongst the precipices and chasms into which ordinary soil is converted by the microscope is well-nigh impossible. By preparing a specially fine mould the difficulty was reduced, and it was hoped that any tendency to burrow into the earth or to encyst in sheltered recesses would at all events be detected. Experiments were made with both wet and dry earth, but here again the results were entirely negative. The mites showed no indication of having attained a desired end, but crawled laboriously among the particles of earth, rearing themselves at intervals and waving their legs as though in the hope of rescue at the eleventh hour by some passing insect. No burrowing, no encystment, no deposition of eggs was noted. For hours, even for days, the mites wandered aimlessly, becoming less and less vigorous till at length they died. On the dry mould they were more active at first, as the wet soil seemed to have a paralyzing effect for the time being. In the latter case the mites, however, lived the longer, several showing signs of life after the third day.

Further experiments were made with black-currant roots which were placed upon the soil and dusted with actively migrating mites. Again nothing definite happened, the mites seemed in no way contented with their new environment, and acted as though the object of their migration were as far from attainment as ever. Such negative results are, of course, inconclusive, but it seems likely that all the mites which fall to the ground are doomed to perish unless they should have the extreme good fortune to be carried by some passing insect to another bush.

#### *Entry into the new Buds.*

During the first week in June the mites were wandering actively about the stems, and some were found in the axils of the leaves, and close to and upon the new buds (Pl. 33. figs. 3, 4). On June 7 a mite artificially placed upon a young bud was seen to work its way in between the sheathing-leaves. New buds were removed at frequent intervals and examined for mites, which were found inside for the first time on June 8. During the ten days of more or less active migration which succeeded, the search for mites was successful in a fair percentage of cases, but from the number of buds which afterwards proved to be diseased it is likely that the presence of one or two of the animals was frequently overlooked—a fact, perhaps, not greatly to be wondered at. The mites in any one bud were always extremely few in number. Till June 12 the weather had been hot and dry, and on that date very few mites were wandering, and those still within the old diseased buds showed slight signs of life. The migration was apparently almost at an end. Rain then fell, and this seemed to revive many of the mites and to prolong the migration period for a few days. With rare exceptions, wandering mites were not seen after June 19, by which time the old abortive buds were entirely lifeless. The migration, therefore, was at an end, and of the hosts of mites in existence at the end of May an infinitesimal number had obtained a footing in the new buds, all the rest having presumably perished.

#### *Behaviour of the Mites within the young Buds.*

The migrating mites were for the most part adult, and eggs could be seen in the transparent bodies of the females (Pl. 33. fig. 7). The date of the deposition of these eggs seemed to be a matter of some importance, though by no means easy to ascertain. The plan of searching for them by the dissection of individual buds was abandoned, but new buds were daily removed from

infested bushes, cut into small fragments, and placed in tubes of spirit. These were shaken vigorously and then allowed to stand, and the sediment examined under the microscope.

Eggs were first found in the buds removed on June 26. After that date they occurred in increasing numbers. By the end of the first week of July the new attack appeared to be firmly established. Mites in all stages of development, as well as eggs, could easily be found by dissection of the new buds, some of which seemed to show signs of abnormal development. In every case the mites were centrally situated in the buds—a remarkable fact in view of their particularly compact structure in this plant, which would render it by no means easy for the immigrant mites to reach the interior.

As the brood increased, the mites worked centrifugally, encroaching gradually upon the more external portions of the bud.

By July 20 the removal of two outside leaves sufficed, in some cases, to reveal the mites, and by the end of the month they were almost external in the most advanced buds, covered only by the loosely applied outermost leaves, while occasionally one or two individuals were found actually on the outside of the buds.

The multiplication of the mites in the new buds had been so rapid during July and August, that it appeared highly probable that a second migration period was approaching. None such, however, was observed. The buds continued to swell, but remained green, and did not burst, and no wandering mites were detected during the autumn. The creatures were now established in their winter-quarters and were reproducing less actively. No new fact was to be added to the record of their life-history. Some might succumb to the rigours of winter, but the survivors would be ready to recommence the life-cycle in the following spring.

#### *Animals associated with the Mite.*

Running with great activity over the twigs of infested bushes, examples of a red mite of the genus *Actineda* were constantly found. No conclusive evidence of its habits was obtained, but one specimen had attached to its jaws what appeared to be empty *Eriophyes*-skins, and it is quite possible that it preys to some extent on the mite, for it belongs to a predaceous group of the Trombidiiidæ.

Within the diseased buds specimens of a *Tyroglyphus* mite were

very frequently observed, and on one occasion, in October, a species of *Tarsonemus* was found. These are vegetable feeders, and could not have been preying upon the *Eriophyes*.

In a large proportion of the mite-infested buds dissection revealed the presence of a small dipterous larva, apparently that of a Cecidomyid fly (Pl. 34. figs. 21, 22). It was hoped that some examples would be reared and the imago obtained and identified, but its development is so slow that larvæ observed in October are little larger than those seen in July, and show no signs of pupation. Probably the fly will not emerge until next spring, when it is quite likely to prove a new species. It is always found at, or near, the centre of the bud, and feeds upon the mites. Its slow growth probably implies a moderation of appetite which allows the mites, by their extreme fertility, to renew their numbers as fast as they are depleted, and thus to keep up the food-supply.

#### *The Red-Currant Plant and the Mite.*

As none of the characteristic swollen buds appeared on red-currant bushes, which, moreover, flourished in the immediate neighbourhood of failing black-currant plants, it was believed that the red-currant was practically immune. When the Cecidomyid larva above mentioned was first observed and some doubt was entertained as to its habits, red-currant buds were examined to see if they contained the grub, the inference being that the presence of the grub would show that it fed upon the bud and not on the mite.

The result of the examination was entirely unexpected, for the *mites* were found in considerable numbers. The attack differed remarkably from that on the black-currant, the infestation working from the outside inwards. At first they were only found in the axils of the leaves at the base of the buds, and perhaps within the first brown sheathing-leaves. Later they penetrated more deeply and had almost reached the centre.

That they were not merely sheltering there but were obtaining nourishment was proved by the presence of eggs and larvæ. No great harm, however, seemed to be done by them, nor were they ever found except on bushes near to badly attacked black-currant plants.



*Conclusions.*

The observations above recorded may be thus briefly summarized :—

1. Of the mites surviving the winter, those which have not succeeded in entirely arresting the growth of the buds, but are driven out by their development before May, probably perish.

2. There is a definite migration period, which takes place as the abortive buds dry up and become uninhabitable, the new buds being then ready for the reception of the mites. In 1901 this period extended from the middle of May to the middle of June. Any mites found wandering in the autumn are probably of the nature of an overflow.

3. Distribution is effected by (1) crawling, (2) adhering to insects, (3) leaping.

4. *There is a brief period when the total number of living mites is exceedingly few, the old buds being dead, while the emigrants which have attained the new buds have not yet increased to any considerable extent. This period in 1901 coincided with the last week in June.*

5. The mites are unable to maintain life in the ground, nor do they attack the roots.

6. The red-currant plant can contract the disease, but does not appear to suffer greatly from it. The mites first appear on the outside of the buds, penetrating inwards as they increase in number.

7. Infested buds very commonly contain a Cecidomyid larva which feeds on the mites.

If the results thus obtained are trustworthy, certain inferences follow with regard to the treatment of the disease. The most important are these :—

1. Any treatment of the ground under infested bushes is unnecessary, as the mites do not live in the soil.

2. Spraying in the early spring is only calculated to destroy mites which would perish in any case.

3. The only time when spraying would be likely to prove beneficial is at the end of May and the beginning of June, when it is undesirable on account of the blossom.

4. The removal of all the new shoots from infested bushes at the end of June, if practicable, would apparently clear the plants of the disease. It is at all events important to remember that at this time the pest is reduced to a minimum.

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*Phytoptus ribis*, Westwood, *Gardeners' Chronicle*, 1869.

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*Eriophyes ribis*, Nalepa, *Das Tierreich*, 1898.

Though references to the black-currant gall-mite, and suggestions for its extermination, are frequent in the writings of economic entomologists, the serious contributions towards our knowledge of its life-history are few in number, and may here be conveniently summarized.

1. NEWSTEAD.—“Recent Investigations on the Currant-bud Mite, *Phytoptus ribis*.” *The British Naturalist*, 1894.

Egg-laying commenced, Feb. 20. Thirty per cent. of the old infested buds dry by May 19. Mites found in the axils of the leaves on June 2. First found within the new buds on July 27, with eggs. No observations made during August. Migration takes place during March.

2. WARBURTON.—“The Black-currant Gall-mite, *Phytoptus ribis*, Westwood.” *The Journal of the Royal Agricultural Society*, 3rd ser. vol. viii. p. 754 (1897).

Eggs found every month except December. Mites migrate during the spring, when slightly infested buds open and badly infested begin to dry up. No means of distribution except by crawling detected. Attempts to ascertain what became of the dislodged eggs unsuccessful.

3. WILSON.—“Disease of the Black Currant caused by the Gall-mite (*Phytoptus ribis*).” Pamphlet issued by the County Council of Fife, Dec. 1898.

A few eggs found in December, numerous in February. Infested buds are dried up in July, before which time the mites wander. Distribution probably largely by wind, and perhaps by insects and birds, but no evidence offered in favour of this suggestion.

## EXPLANATION OF THE PLATES.

## PLATE 33.

Fig. 1. Twig of black currant showing diseased buds. From the apex to the point marked A is the current year's growth; between A and B is last year's wood with the buds which shrivelled at the end of June 1901; below B is older wood with dry brown buds which dried in the summer 1900.

- Fig. 2. Diseased buds which have managed to produce dwarfed leaves.
3. New bud at the time when the mites are establishing themselves in it, and are now to be seen on the outside.
  4. Fig. 3 magnified.
  5. A piece of diseased bud, showing the mites and eggs *in situ*.
  6. Two mites in the erect position, prior to leaping.
  7. Lateral view of mite as seen when crawling, drawn on a .5 mm. chart. (Ultimate divisions =  $\frac{1}{20}$  mm.)
  8. Leg of mite, showing the "feather-hair" and bristles.
  9. Posterior extremity of mite, showing the tail-disc and two bristles when in the erect attitude assumed before leaping.

#### PLATE 34.

- Fig. 10. Dorsal view of the anterior end of the mite, showing the characteristic sculpturing of the "carapace."
11. Ventral view of same, with the mouth-parts (*m.*) and external sexual organs (*s.*).
  12. Dorsal view of posterior end.
  13. Ventral view of posterior end.
  14. Diagrammatic representation of the positions assumed by the mite while endeavouring to obtain a firm hold by its tail before standing erect.
  15. Showing how the erect attitude is assumed.
  16. An egg, drawn on a .1 mm. chart. (Ultimate divisions =  $\frac{1}{100}$  mm.)
  17. An egg at a later stage, with the contained mite, ready for hatching.
  18. Larval form of the mite.
  19. Mite about to undergo ecdysis.
  20. Mite crawling, as seen from above.
  21. Cecidomyid larva found in the diseased buds—lateral view:—  
*m.* = mouth, *s.* = spiracle, *t.* = trachea.
  22. Magnified drawing of anterior end of the Cecidomyid larva.

[Figs. 7, 10, 11, 16, 18, 19 drawn by the "camera lucida."]

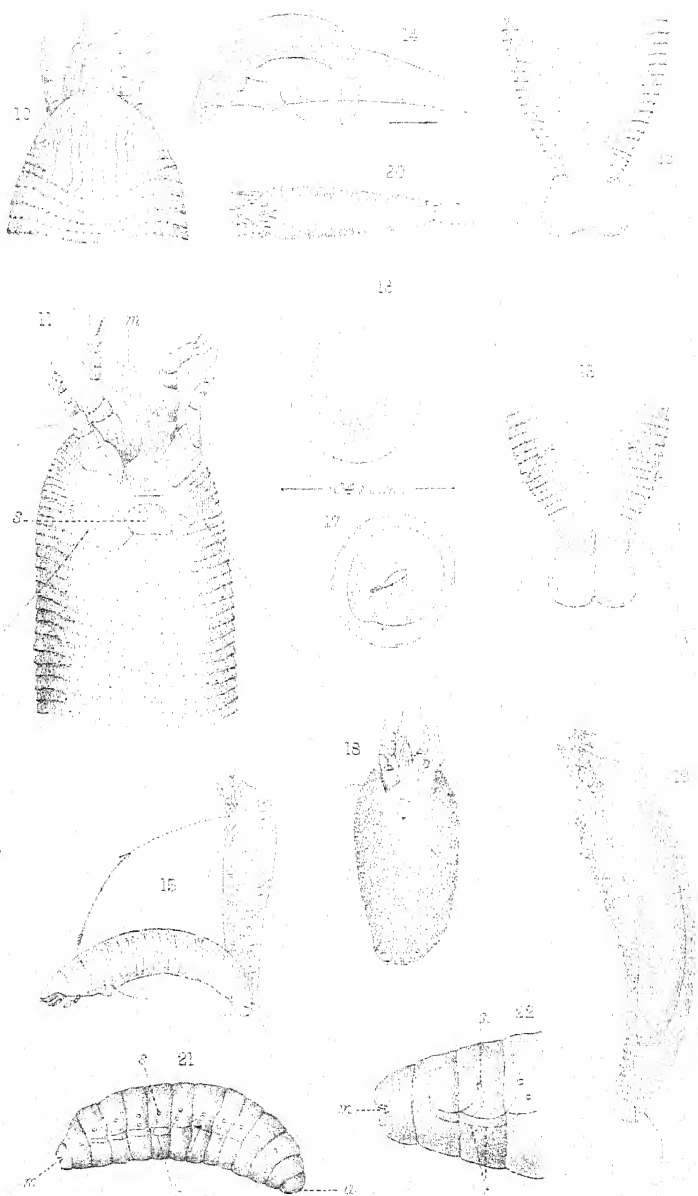


Michael Emerson defendant  
v. Richmond Ind.

West, Newman. imp.

ERIOPHYES (PHYTOPTUS) RIBIS.





Allice L. Emberson del. ad nat.  
A. R. Hammond lith.

West Newman imp.

ERIOPHYES (PHYTOPTUS) RIBIS.



On the FORAMINIFERA collected round the Funafuti Atoll from Shallow and Moderately Deep Water. By FREDERICK CHAPMAN, A.L.S., F.R.M.S.

[Read 5th December, 1901.]

(PLATES 35 & 36.)

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#### I. INTRODUCTORY REMARKS.

The collections upon which the following results are based are these:—

- (1) A series of shore-sands from the ocean and lagoon-beaches of the Funafuti Atoll. Obtained by Prof. W. J. Sollas, F.R.S., during the first expedition to Funafuti in 1896.
- (2) Samples from the rocks forming the seaward slope of the reef at depths from 16-200 fathoms, obtained by means of heavy steel chisels and tangles; also samples of sand from various depths. Collected by Prof. Edgeworth David and Mr. Woolnough in 1897.
- (3) A series of sand and reef-rocks collected by Messrs. G. Halligan and A. E. Finckh round the Atoll at depths down to 240 fathoms. Also soundings and dredgings taken along a line due west from Tutanga. Collected in August 1898.



During my microscopical examination of the thin slices of the cores brought up by the boring operations at Funafuti it was evident that, in order to arrive at some definite conclusions respecting the meaning of the various changes in the facies of the foraminifera and other microzoa found at different levels, we ought to know more about the actual distribution of the microzoa living round the atoll and in the lagoon. By a careful study of the differences in the distribution of the smaller organisms it is possible to gain information of considerable value as to the depth at which they best developed, and also with regard to the accompanying physical or hydrographical conditions. The present paper should therefore serve as a basis for the discussion of the significance of the contents of the core as far as the foraminifera are concerned (and these organisms, by the way, constitute the greater proportion of the Funafuti core), since the results are derived from samples obtained from fairly shallow-water deposits, speaking in the hydrographical sense.

This interesting subject, in its bearing on the contents of the core, may be discussed in a later paper of this series.

The deep-sea soundings taken round Funafuti are also of considerable interest, and their description may be reserved for another paper on the subject.

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## II. FORAMINIFERA *from the OCEAN-BEACHES, FUNAFUTI,* *from material collected by Prof. SOLLAS, 1896.*

NOTE.—The actual label-names attached to the samples of sands have the following signification, and the native name alone is here retained:—"Our Islet" = Fongafale Islet or Funafuti Island; "South Island" = Avalau Islet; "Gold Island" = Fualopa Islet.

The following terms in the Table denote the relative abundance of the specimens:—v.r.=very rare; r.=rare; f.=frequent; c.=common; v.c.=very common; ex.c.=excessively common.

	Name.	N. end Fongafale Islet.	Avalau Islet.	Fualopa Islet.
1.	<i>Nubecularia lucifuga</i> , Defr. ....	.....	...	v.r.
2.	" <i>Bradyi</i> , Millett .....	.....	f.	
3.	" <i>lacunensis</i> , Chap. ....	.....	f.	
4.	" <i>divaricata</i> , Brady .....	.....	f.	
5.	<i>Biloculina irregularis</i> , d'Orb. ....	.....	f.	
6.	" <i>ringens</i> (Lam.) .....	.....	...	f.
7.	<i>Spiroloculina nitida</i> , d'Orb. ....	.....	v.r.	
8.	" " var. <i>foveolata</i> , Egger .....	.....	f.	
9.	" <i>canaliculata</i> , d'Orb. ....	.....	v.r.	
10.	" <i>acutimargo</i> , Brady .....	.....	f.	
11.	" <i>antillarum</i> , d'Orb. ....	.....	f.	
12.	" <i>grata</i> , Terg. ....	.....	f.	
13.	" <i>crenata</i> , Karrer. ....	.....	v.r.	
14.	<i>Miliolina circularis</i> (Born) .....	.....	c.	
15.	" " var. <i>sublineata</i> , Brady .....	.....	v.r.	
16.	" <i>subrotunda</i> (Mont.) .....	.....	v.r.	
*17.	" <i>labiosa</i> (d'Orb.) .....	.....	c.	
18.	" <i>trigonula</i> (Lam.) .....	.....	v.r.	
19.	" <i>oblonga</i> (Mont.) .....	.....	c.	
20.	" <i>Bosciana</i> (d'Orb.) .....	.....	f.	
21.	" <i>seminulum</i> (L.) .....	.....	f.	
22.	" <i>funafutiensis</i> , Chap. ....	.....	v.r.	
23.	" <i>Boueana</i> (d'Orb.) .....	.....	v.r.	
24.	" <i>Cuvieriana</i> (d'Orb.) .....	.....	f.	f.
25.	" <i>tricarinata</i> (d'Orb.) .....	.....	v.r.	
26.	" " var. <i>Bertheliniana</i> , Brady. ....	.....	c.	c.
27.	" " var. <i>Terquemiana</i> , Brady. ....	.....	v.r.	
28.	" <i>hicornis</i> (W. & J.) .....	.....	...	v.r.
*29.	" <i>agglutinans</i> (d'Orb.) .....	.....	c.	
*30.	" <i>Ferussacii</i> (d'Orb.) .....	.....	c.	f.
31.	" <i>Linneana</i> (d'Orb.) .....	.....	f.	
32.	" <i>undosa</i> (Karrer) .....	.....	f.	
33.	" <i>reticulata</i> (d'Orb.) .....	.....	v.c.	v.c.
34.	" <i>Parkeri</i> (Brady) .....	.....	f.	f.
35.	<i>Articulina funalis</i> , var. <i>inornata</i> , Brady...	.....	v.r.	
36.	<i>Hauerina compressa</i> (d'Orb.) .....	.....	f.	
37.	" <i>ornatissima</i> (Karrer) .....	.....	v.r.	
38.	<i>Planispirina exigua</i> , Brady .....	.....	f.	
39.	<i>Sigmoilina celata</i> (Costa) .....	.....	f.	
40.	<i>Cornuspira involvens</i> , Reuss .....	.....	v.c.	
41.	<i>Peneroplis pertusus</i> (Forskål) .....	.....	c.	
42.	" <i>arictinus</i> (Batsch) .....	.....	f.	
*43.	" ( <i>Monalysidium</i> ) <i>cylindraceus</i> (Lam.) .....	.....	f.	
44.	" ( <i>M.</i> ) <i>lituus</i> (Gmelin) .....	.....	v.r.	
45.	" ( <i>M.</i> ) <i>Sollasi</i> , Chap. ....	.....	v.r.	
46.	<i>Orbitolites marginalis</i> (Lam.) .....	f.	ex.c.	c.
47.	" <i>duplex</i> , Carpenter .....	.....	f.	
48.	" <i>complanata</i> , Lam. ....	v.c.	f.	ex.c.

\* See notes appended to this list.

	Name.	N. end Fongafale Islet.	Avalau Islet.	Fualopa Islet.
*49.	<i>Orbitolites complanata</i> , var. <i>plicata</i> (Dana)	.....	...	r.
*50.	<i>Haddonina minor</i> , sp. nov.	.....	v.r.	
51.	<i>Textularia rugosa</i> (Reuss)	.....	r.	
52.	" <i>conica</i> , d'Orb.	.....	f.	
*53.	<i>Verneuilina spinulosa</i> (Reuss)	.....	r.	
54.	<i>Valulina Davidiana</i> , Chap.	.....	r.	
55.	<i>Clavulina angularis</i> , d'Orb.	.....	f.	
56.	<i>Bolivina limbata</i> , Brady	.....	f.	
57.	" <i>tortuosa</i> , Brady	.....	v.r.	
58.	<i>Sagrina raphanus</i> , P. & J.	.....	c.	
59.	<i>Globigerina sacculifera</i> , Brady	.....	v.r.	
60.	<i>Spirillina vivipara</i> , Ehr.	.....	v.r.	
61.	" <i>inequalis</i> , Brady	.....	r.	v.r.
62.	" <i>spinigera</i> , Chap.	.....	v.r.	
*63.	<i>Patellina corrugata</i> , Will.	.....	v.r.	
64.	<i>Cymbalopora Poeyi</i> (d'Orb.)	.....	c.	c.
*65.	" var. <i>squamosa</i> (d'Orb.)	.....	f.	
66.	" <i>tabellæformis</i> , Brady	.....	r.	r.
67.	" ( <i>Tretomphalus</i> ) <i>bulloides</i> (d'Orb.)	.....	v.r.	
68.	<i>Discorbina araucana</i> (d'Orb.)	.....	...	v.r.
69.	" <i>Vilardeboana</i> (d'Orb.)	.....	v. l.	
70.	" <i>rosacca</i> (d'Orb.)	.....	r.	
71.	" <i>rugosa</i> (d'Orb.)	.....	v.r.	
72.	" <i>globularis</i> (d'Orb.)	.....	f.	v.r.
73.	" <i>tabernacularis</i> , Brady	.....	f.	
*74.	" <i>acuminata</i> , sp. nov.	.....	r.	
75.	" <i>concinna</i> , Brady	.....	r.	
76.	" <i>orbicularis</i> (Terq.)	.....	c.	v.r.
77.	<i>Planorbulina larvata</i> , P. & J.	.....	v.r.	
78.	" <i>acervalis</i> , Brady	.....	c.	
*79.	" <i>retinaculata</i> , P. & J.	.....	r.	
80.	<i>Truncatulina lobatula</i> (W. & J.)	.....	v.r.	
81.	" <i>variabilis</i> (d'Orb.)	.....	v.r.	
82.	" <i>rostrata</i> , Brady	.....	v.r.	
83.	" <i>reticulata</i> (Czizek)	.....	v.r.	
84.	<i>Anomalina coronata</i> (P. & J.)	.....	r.	
*85.	<i>Calcarina Spengleri</i> (L.)	.....	...	f.
86.	" <i>hispida</i> , Brady	.....	v.c.	f.
87.	" var. <i>pulchella</i> , Chap.	.....	f.	
88.	<i>Tinoporus baculatus</i> (Montf.)	c.	ex.c.	ex.c.
*89.	" var. <i>florescens</i> , nov.	.....	r.	
90.	<i>Gypsina inherens</i> (Schultze)	.....	v.r.	f.
91.	" <i>globulus</i> (Reuss)	.....	v.r.	v.r.
92.	<i>Polytrema miniaceum</i> (Pallas)	c.	v.r.	c.
93.	<i>Polystomella striatopunctata</i> (F. & M.)	.....	f.	
94.	" <i>macella</i> (F. & M.)	.....	v.r.	
95.	" <i>crispa</i> (L.)	.....	r.	
96.	<i>Amphistegina Lessonii</i> , d'Orb.	c.	ex.c.	ex.c.
97.	<i>Heterostegina depressa</i> , d'Orb.	.....	f.	f.

\* See notes appended to this list.

Of the foregoing samples of foraminiferal sands from the seaward beaches of Funafuti, that from Avalau Islet is by far the richest in organisms. The Foraminifera are there in great profusion, and the species very numerous for a coral area; the specimens themselves are beautifully preserved, even down to the most delicate ornamentation of spines and the perfect contour of the shell in many of the fragile forms.

Besides the Foraminifera we find in the sand of Avalau Islet fragments of calcareous Algæ, spicules of a Calcsponge, Alcyonarian spicules, a few Heteropods and numerous Ostracoda; the valves of the last-named organisms are more than usually abundant and varied, and these, together with other Ostracoda from Funafuti, will be enumerated and described in a separate paper.

The sand here examined from Fongafale Islet is water-worn and perhaps wind-polished, so that the result—the occurrence of five species only of Foraminifera—is not surprising.

We now proceed to the description of new species, and notes on the more remarkable forms of the Foraminifera occurring in the beach-sands of Funafuti.

*Notes on the Foraminifera of the Beach-Sands, Funafuti.*

*MILIOLINA LABIOSA (d'Orbigny).*

The specimens from Avalau Islet exhibit the same tendency to merge into *Nubecularia Bradleyi*, Millett, by growing irregularly in a lateral direction until the milioline character is entirely lost, which Millett remarks in his description of the Malay foraminifera \*. There are apparently no specimens from Funafuti, such as were found in the Malay soundings, which pass into *Miliolina valvularis* (Reuss).

*MILIOLINA AGGLUTINANS (d'Orb.).*

The form which is rather frequent at Avalau Islet partakes of the general characters of *M. Bosciiana* (d'Orb.), and might perhaps with equal reason be assigned to that species. Millett figures a similar example from the Malay Archipelago †.

*MILIOLINA FERUSSACII (d'Orb.).*

Probably more than half the number of specimens from Funafuti are represented by the flattened costate variety, formed

\* Journ. R. Micr. Soc. 1898, p. 502.

† *Tom. cit.* p. 268, pl. iv. figs. 4 a-c.

almost on a spiroloculine plan, similar to the figure given by Millett of his Malay specimens\*.

*PENEROPLIS (MONALYSIDIUM) CYLINDRACEUS (Lam.).*

A very delicate little form, which by its thin shell-structure and simple oral aperture seems to belong to the subgeneric type *Monalysidium*.

*ORBITOLITES COMPLANATA, Lam., var. Plicata, J. D. Dana.*

*Marginopora vertebralis*, Blainville, var. *plicata*, Dana, 1848, in Wilkes' United States Exploring Expedition Reports, "Zoophytes," p. 706, [in vol. of plates referred to as *Marginopora vertebralis*?] pl. 60. figs. 9 a, b.

*Orbitolites laciniatus*, Brady, 1881, Quart. Journ. Micr. Sci. vol. xxi. N. S. p. 47.

*O. complanata*, var. *laciniata*, Carpenter, 1883, Report on the Genus *Orbitolites*, Zool. Chall. Exp. part xxii. pl. vii.

This is the well-known thick variety of *Orbitolites* with the plicated margin, and which Brady showed to be a stage of shell-growth dependent on a phase of reproduction, since the edge bears chamberlets with megalospheric young. J. D. Dana described this variety as *plicata* in 1848, and H. B. Brady appears to have overlooked this when he described his specimens from Fiji and elsewhere.

*HADDONIA MINOR*, sp. nov. (Pl. 36. figs. 1, 2.)

Test attached by the earlier segments, which are frequently grouped in a triserial manner, as in *Verneuilina*, &c.; afterwards growing erect or in a vermiform fashion, similar to *H. Torresiensis*, but is much smaller. Aperture horseshoe-shaped.

Average length of test 2-4 mm.; average diameter .7 mm.

Avalau Islet; very rare.

*VERNEUILINA SPINULOSA (Reuss).*

The specimens from Avalau Islet are in very fine condition, and the spinous processes are exceptionally long.

*PATELLINA CORRUGATA, Williamson.*

It is very unusual to find this species in low latitudes, but it is not unknown from such localities; it has, for instance, been recorded from Mauritius and elsewhere. It is, however, more abundant in temperate and colder areas.

\* Journ. R. Micr. Soc. 1898, p. 507, pl. xii. figs. 7 a-c.

CYMBALOPORA POEYI, var. squamosa (d'Orb.).

*Rotalia squamosa*, d'Orb., 1826, Ann. Sci. Nat. vol. vii. p. 272. no. 8.

*Rosalina squamosa*, d'Orb., 1839, Foram. Cuba, p. 100, pl. iii. figs. 12-14.

*Cymbalopora Poeyi*, d'Orb., depressed var., Brady, 1884, Rep. Chall. vol. ix. p. 637, pl. cii. figs. 14 a-d.

This variety is a neat depressed form of the heavier sub-conical specific type; in its earlier stages it is sometimes found parasitic upon algæ.

DISCORBINA ACUMINATA, sp. nov. (Pl. 36. fig. 3.)

Test conical, elongate; the apex terminating in a sharp point. The inferior face deeply sunken. Chambers arranged in about six whorls, the segments long and set obliquely. Surface of test ornamented with radiating striæ centred in the apex and the umbilicus respectively. Height .3 mm.; diameter .2 mm.

Although *D. acuminata* is related to *D. tabernacularis*, Brady, it differs in having straighter and longer sides to the cone and a pointed aboral extremity.

Shore-sand, Avalau Islet, Funafuti; rare.

PLANORBULINA RETINACULATA, Parker & Jones.

*Planorbulina retinaculata*, P. & J., Phil. Trans. vol. clv. 1865, p. 380, pl. xix. fig. 2.

A wild-growing modification of *P. mediterraneensis*, d'Orbigny, parasitic on shells or algæ, in which the chambers of the later whorls are partially separated, and bear numerous apertures especially around the periphery of the test. Parker and Jones's specimens were found in the West Indies. This form is especially worthy of notice, as it does not appear to have occurred often, if at all, since the original description was published. *P. retinaculata* occurs at Funafuti detached from their surfaces of support and mingled with the sand.

CALCABINA SPENGLERI (Linné).

This species appears to be almost exclusively confined to the East Indian Archipelago, and therefore its occurrence at Funafuti in at least one of the samples of beach-sands is interesting as adding to its geographical range. The Funafuti specimens are small but typical.

TINOPORUS RACULATUS (*Montfort*), var. FLORESCENS, nov.

(Pl. 36. fig. 4.)

This variety has its distinguishing feature in the curious dehiscient or florescent terminations of the spurs of the test. This is proved by thin sections to be formed by the redundant overgrowth of the acervuline or compressed outer layers of chamberlets upon the intermediate shell-growth forming the spurs. This overgrowth is very thin, and covering the spurs forms a recurved edge around their extremities. Occurs at Avalau Islet.

### III. FORAMINIFERA from the LAGOON-BEACHES, FUNAFUTI.

Two samples of the foraminiferal sand of the lagoon-beaches are noticed here, with the species of foraminifera found therein. One is from Funafuti Island (Fongafale I.), collected by Prof. Sollas in 1896; the other from the S.E. of the Atoll at Funafala Islet, collected by Messrs. Halligan and Finckh in 1898.

The dredgings taken across the lagoon commencing off Fongafale at a depth of 10 fathoms have been microscopically examined for foraminifera and already reported upon\*.

	Name.	Lagoon-beach at Fongafale I.	Lagoon-beach S. end of Funafala I.
1.	<i>Nubecularia divaricata</i> , Brady .....	.....	v.r.
2.	" <i>lucifuga</i> , DeFrance .....	v.r.	
3.	" <i>lacuensis</i> , Chapman .....	.....	v.r.
4.	<i>Spiroloculina nitida</i> , d'Orb.....	.....	r.
5.	" " var. <i>foveolata</i> , Egger. ....	.....	v.r.
6.	" <i>grata</i> , Terq.....	.....	r.
7.	" <i>antillarum</i> , d'Orb. ....	.....	v.r.
8.	<i>Miliolina seminulum</i> (L.).....	.....	c.
9.	" <i>oblonga</i> (Mont.) .....	v.r.	
10.	" <i>trigonula</i> (Lam.).....	.....	r.
11.	" <i>tricarinata</i> (d'Orb.), var. <i>Ber-</i> <i>theliniana</i> , Brady. ....	f.	v.r.
12.	" <i>tricarinata</i> , var. <i>Ter-</i> <i>quemiana</i> , Brady. ....	f.	
13.	" <i>reticulata</i> (d'Orb.) .....	r.	c.
14.	" <i>Ferussacii</i> (d'Orb.) .....	.....	v.r.
15.	<i>Peneroplis pertusus</i> (Forskål) .....	.....	f.
16.	" <i>arietinus</i> (Batsch) .....	.....	r.
17.	<i>Orbitolites complanata</i> , Lam. ....	v.c.	v.c.
18.	" <i>marginalis</i> (Lam.) .....	r.	c.

\* See Journ. Linn. Soc., Zool. vol. xxviii. pp. 161-210.

	Name.	Lagoon-beach at Fongafale I.	Lagoon-beach S. end of Funafala I.
19.	<i>Textularia gramen</i> , d'Orb. ....	.....	v.r.
20.	„ <i>rugosa</i> (Reuss) .....	.....	f.
21.	„ <i>siphonifera</i> , Brady.....	.....	v.r.
22.	<i>Clavulina angularis</i> , d'Orb.....	.....	v.r.
23.	<i>Valvulina Davidiana</i> , Chapman.....	.....	v.c.
24.	<i>Sagrina raphanus</i> , Parker & Jones ..	.....	f.
25.	<i>Cymbalopora Poeji</i> (d'Orb.) .....	v.r.	c.
26.	<i>Discorbina globularis</i> (d'Orb.).....	.....	v.r.
27.	<i>Truncatulina Akneriana</i> (d'Orb.) .....	.....	v.r.
28.	<i>Calcarina hispida</i> , Brady.....	c.	v.c.
29.	<i>Tinoporus baculatus</i> (Montf.) .....	ex.c.	v.c.
30.	<i>Gypsina inhærens</i> (Schultze) .....	v.r.	
31.	„ <i>vesicularis</i> (P. & J.) .....	v.r.	
32.	<i>Polytrema miniaceum</i> (Pallas).....	c.	c.
33.	<i>Amphistegina Lessonii</i> , d'Orb.....	ex.c.	v.c.
34.	<i>Heterostegina depressa</i> , d'Orb.....	v.r.	v.r.

IV. A DESCRIPTION of the REEF-FRAGMENTS obtained from the REEF-FACE, FUNAFUTI, upon which ADHERENT FORAMINIFERA have been found.

It seems desirable to keep the description of this series of specimens distinct from the foraminiferal sands, chiefly in order to show how important a part the larger encrusting and adherent foraminifera play in forming the growing reef, a fact which has been brought into prominence by the evidence of the Funafuti collections, both of the core and the samples dredged up from the living reef. These reef-samples are here arranged, firstly, in their order of position around the Atoll from N., E., S., to W., and, secondly, in the order of the depth from which they were dredged. The foraminiferal sands which are described subsequently are arranged in order of depth; the bathymetrical distribution of the various organisms may thus be readily seen.

N.W. of Pava I., 63 fathoms (1897).

Two reef-specimens. (1) An encrusting mass of *Polytrema planum* measuring 3 cm.  $\times$  2.75 cm. This specimen was evidently torn off the reef at a weak point of attachment. It is smooth exteriorly, with a slightly undulate surface, and shows on the under, attached, surface a rudely concentric manner of growth.



At one side of this specimen a full-grown megalospheric test of *Cycloclypeus Carpenteri* has been partially encrusted and overgrown by the *Polytrema*.

Pava I., 240 fathoms (1898).

*Specimen A 51.*

A deep-sea coral with numerous adherent tests of *Carpenteria balaniformis*, and a doubtful specimen of *C. rhabdodendron*.

Funamanu (Beacon Id.), 25 fathoms.

An alcyonarian stem encrusted in places with a pale green *Polytrema planum* and a species of bryozoa, and bearing on its surface numerous specimens of *Carpenteria monticularis*, *C. utricularis*, and *Polytrema miniaceum*.

Funamanu (Beacon Id.), 45 fathoms (coll. A).

A somewhat thin and flexuose piece of reef-rock measuring 5 cm.  $\times$  3 cm., encrusted with algæ, foraminifera, hydrozoa, and bryozoa.

The foraminifera are *Polytrema planum* and *P. miniaceum*, both represented only by young growths.

Funamanu (Beacon Id.), 50 fathoms (1897).

*Specimen C 1.*

Coral-rock encrusted with *Lithothamnion Philippii* var. *funafutiensis*, *Carpenteria monticularis*, *Polytrema planum*, *P. miniaceum* and var. *alba*, *Serpulæ*, and bryozoa.

*Specimen C 2.*

A thin fragment of coral-rock with adherent organisms—*Lithothamnion*, foraminifera, *Serpulæ*, and bryozoa. The foraminifera are *Sagenina frondescens*, *Bdelloidina aggregata*, *Carpenteria monticularis*, *C. utricularis*, and *Polytrema miniaceum*.

(2) Another specimen of *P. planum* growing on a base of hard ? coral-rock, measuring 3 cm.  $\times$  2 cm. The *Polytrema* has grown irregularly, forming thin layers. On the rougher side of this specimen *Carpenteria monticularis* occurs, and here and there are little patches of the pink *Polytrema miniaceum*.

## Off Funamanu (Beacon Id.), 80 fathoms (1897).

*Specimen C 6.*

An axis of a Gorgoniid with an encrusting *Lithothamnion* and bryozoa, also some adherent foraminifera and *Serpulæ*. The foraminifera are *Carpenteria monticularis*, *Polytrema miniaceum*, and *P. planum*. Another similar fragment (see Pl. 35. fig. 2) shows, in addition to the above species, a good example of *Carpenteria utricularis* and a large mass of *Carpenteria raphidodendron*.

## Off Funamanu (Beacon Id.), 80 fathoms (1898).

*Specimens A 22.*

Several fragments broken from the reef; some consisting almost entirely of successive layers of *Polytrema planum* having a snowy or frothy texture and appearance. Two of the fragments have well-developed specimens of *Carpenteria raphidodendron* adhering to their surfaces, one of them measuring 3 cm. in height. A fragment of *Turbinaria* perforated by *Cliona* carries several specimens of *Haddonina torresiensis* on one surface, and on the opposite face numerous bryozoa, a sponge, *Halimeda*, and the pink encrusting *Lithothamnion Philippii* var. *funafutiensis*, and the following foraminifera:—*Carpenteria monticularis*, *C. utricularis*, and *Polytrema miniaceum* in a young stage of growth.

*Specimen A 24.*

Two fragments of reef-rock, the upper surfaces of which are entirely overgrown with pure white examples of *Polytrema planum*. On the under surface bryozoa, *Serpulæ*, and *Polytrema miniaceum* occur.

## Falefatu, 38 fathoms (1898).

*Specimen A 19.*

A piece of hard calcareous rock, measuring 18×11×4 cm., overgrown on the upper surface with knobs and crusts of *Lithothamnion Philippii* var. *funafutiensis*, *Psammocora* sp., bryozoa, and brachiopoda (*Crania*). Also the foraminifera *Polytrema planum* and *P. miniaceum*. The corals are chiefly adherent to

the upper (cleaner) surface, the bryozoa on the lower surface, whilst *P. planum* and *P. miniaceum* are on both surfaces.

Off Tutanga, 60–100 fathoms (1898).

*Specimen A 35.*

A fragment of reef-rock measuring 7.5 × 4.5 cm., encrusted with *Polytrema planum*, which almost completely covers the specimen. There are also a few thin crusts of *Lithothamnion Philippii* var. *funafutiensis* associated with it, and an example of *Cycloclypeus Carpenteri* (form B), measuring 2.5 cm. in diameter. The base of the rock is cavernous and drilled by boring organisms.

Off Tutanga, 115–200 fathoms (1898).

*Carpenteria balaniformis* very numerous on deep-sea corals (*Oculinidæ*).

Off Tutanga, 117 fathoms (1897).

*Specimen A 32.*

A rough, irregular fragment of reef-rock, measuring about 10 × 9 × 6 cm., consisting of an aggregate of organisms, as foraminifera, minute corals, hydrozoa, and *Serpulæ*, solidified by intergrowth and encrustation. By far the larger mass of the rock is formed of the encrusting and cementing organism *Polytrema planum*, which here still retains the pale green colour so frequently seen in living specimens. This green coloration gives to the *Polytrema* an illusionary resemblance to an alga. The large form (B) of *Cycloclypeus Carpenteri* is represented in this block by a specimen measuring 5 cm. in diameter, whilst there are numerous examples of the smaller form (A) embedded between the other organisms.

Off Tutanga, 135 fathoms (August 1898).

*Specimen B 7.*

A collection of reef-fragments ; consisting of some large masses of *Polytrema planum* (see Pl. 35. fig. 4), one or two measuring about 5 cm. square ; some lamellibranch shells overgrown inside and out with *Serpulæ* and *Polytrema planum* ; fungoid corals accreted with growing organisms, chiefly *Polytrema planum* ; a fragment of an alcyonarian stem measuring 4.5 cm. in length

and having a diameter of 1.8 cm., encrusted with *Polytrema planum*, which has ensured its preservation.

Dredgings taken near Tutanga (bearing 102° to Tutanga, 155° to Tegasu), 136 fathoms (1897).

Fragmentary rock-specimens and *Halimeda*-joints. One piece consisting of an encrusting mass of *Polytrema planum* measures 3 × 2 cm. and is 4 mm. thick. The outer surface is smooth and of a very pale green colour. To the under surface a fine specimen of *Haddonina torresiensis* is attached.

The smaller fragments bear numerous dark-coloured specimens of *Polytrema miniaceum*.

A fragment of Alcyonarian largely composed of the agglutinated spicules.

Associated with these are *Sagenina frondescens* (on *Halimeda*) and *Cycloclopeus Carpenteri* (form A).

Dredgings west of Tutanga, 200 fathoms.

*Specimen A 2.*

Two rather massive pieces of organic calcareous rock and fragments of a Gorgoniid stem.

The largest piece of rock measures 12.5 × 6 × 3.5 cm., and consists of large flaky masses of *Polytrema planum* built in tiers, rudely resembling the nest of the wasp (*Vespa*); with many adherent foraminifera, bryozoa, *Serpulæ*, brachiopoda (*Crania*), and algæ. Besides *P. planum* the other foraminifera are *Polytrema miniaceum*, whose small pustular tests are scattered over a large portion of the rock, and *Carpenteria serialis*, sp. nov. (Pl. 35. fig. 3). There are apparently two kinds of algæ—one a thin, pink, encrusting form, and the other a thread-like or filamentose and branching organism rather doubtful in its affinity.

The smaller piece of rock measures 8.5 × 5 × 2.5 cm., and has a double nodular shape, with a lumpy surface, overgrown with *Polytrema planum*, *P. miniaceum*, and several species of bryozoa.

The alcyonarian stems are encrusted with a pink alga, and foraminifera (as *Carpenteria utricularis*, *Polytrema miniaceum*), a sponge, and numerous bryozoa.

## South of Fuafatu, 25 fathoms (August 14th, 1897).

Reef-fragments with broken shells and many foraminifera. The latter are:—

*Orbitolites complanata*, rare.

*Sagenina frondescens*, common and well-grown, on shells and *Halimeda*.

*Planorbulina acervalis*, very rare, on *Halimeda*.

*Polytrema planum*, on *Halimeda*, and forming button-like masses.

*P. miniaceum*, very common.

## Off Fuafatu, 60 fathoms (1897).

*Specimen C 4.*

A flat piece of coral covered with pink *Lithothamnion*, foraminifera, *Serpulæ*, bryozoa, and brachiopoda (*Crania*).

The foraminifera are *Sagenina frondescens*, *Haddonia torresiensis*, and *Polytrema miniaceum*.

## Off Fuafatu, 60 fathoms (1897).

*Specimen C 3.*

Coral-rock encrusted with *Lithothamnion*, *Polytrema planum*, and bryozoa.

## S.S.W. of Fuafatu, 60 fathoms (1897).

*Specimen C 5.*

Calcareous rock encrusted with *Lithothamnion*, foraminifera, a small coral, *Serpulæ*, and bryozoa.

The foraminifera are *Haddonia torresiensis*, *Carpenteria monticularis*, and *Polytrema miniaceum*.

## South of Fuafatu, 119 fathoms (1897).

Reef-fragments, one of which measures 2.5 × 2 cm. It is encrusted with *Polytrema planum* to which are attached several specimens of *Haddonia torresiensis*. There are also specimens of *Cycloclypeus Carpenteri* (form A) in the accompanying sand.

TABLE illustrating the DISTRIBUTION of REEF-FORMING FORAMINIFERA (*adherent and encrusting species*) round the Atoll of Funafuti\*.

Name.	Localities.	Depths in fathoms.	Conditions of growth.
1. <i>Sagenina frondescens</i> (Brady).	Pava, Funamanu, Tutanga, and Fuafatu.	30, 36, 50, 60, 136, 150, 200.	Found chiefly on <i>Halimeda</i> joints.
2. <i>Haddonella torresiensis</i> , Chapman. (Pl. 35, figs. 1 & 1 a.)	Pava, Funamanu, Tutanga, and Fuafatu.	25, 35, 40, 60, 80, 119, 136.	Adherent to reef-rock and reef-organisms.
3. <i>Bdelloidina aggregata</i> Carter.	Pava and Funamanu.	25, 50, 60, 63.	Found growing on reef-rock, millepores, corals, and molluscan shells.
4. <i>Carpenteria utricularis</i> , Carter.	Pava, Funamanu, Tutanga, and Fuafatu.	25, 50, 57, 60, 80, 94, 136, 150, 200.	Grows attached to <i>Halimeda</i> , Alcyonarian stems, millepores, or bare reef-rock.
5. <i>Carpenteria halaniformis</i> , Gray.	Pava and Tutanga.	115-240.	Growing on deep-sea corals and <i>Serpula</i> .
6. <i>Carpenteria monticularis</i> , Carter.	Funamanu, Tutanga, and Fuafatu.	25, 50, 60, 80, 86, 135, 200.	Growing attached to <i>Polytrema planum</i> , Alcyonarian stems, molluscan shells, or bare reef-rock.
7. <i>Carpenteria rhabdodendron</i> , Möbius. (Pl. 35, fig. 2.)	? Pava; Funamanu and Fuafatu.	60, 80, ? 240.	Found only at two or three depths. Grows in massive clusters, throwing out tubes which are often joined terminally by a platform-like growth of <i>Polytrema planum</i> .
8. <i>Carpenteria serialis</i> , sp. nov. (Pl. 35, fig. 3.)	Tutanga.	200.	Attached to reef-fragments.
9. <i>Polytrema planum</i> (Carter). (Pl. 35, figs. 2 & 4.)	Pava, Funamanu, Falefatu, Tutanga, Fuafatu.	25, 38, 45, 50, 60, 63, 80, 117, 119, 136, 136, 200.	Found encrusting reef-rocks and rounding off sharp angular fragments by wrapping them in successive layers of acervuline cells until the original contour entirely disappears. It even grows over living organisms, such as <i>Cycolypeus</i> , until they are quite covered up by the rapid growth of the foraminifera.
10. <i>Polytrema miniaceum</i> (Pallas).	Funamanu, Falefatu, Tutanga, and Fuafatu.	25, 38, 45, 50, 60, 80, 136, 200.	Growing profusely on <i>Polytrema planum</i> , <i>Halimeda</i> joints, or reef-rock.
11. <i>Polytrema miniaceum</i> , var. <i>alba</i> , Carter.	Funamanu.	50.	Associated with <i>P. miniaceum</i> but very rare.

\* This table includes data given in my earlier paper on the same subject. See Journ. Linn. Soc., Zool. vol. xxviii. pp. 1-27.

Besides the foregoing adherent foraminifera, the ordinary species of smaller dimensions which live freely on the reef play an important part by the enormous quantities of their tests which speedily become encrusted and consolidated by the growth of organisms. A cavernous rock is thus formed, the interstices of which do not become filled until a much later date in the history of the reef-formation.

Such noteworthy species are *Amphistegina Lessonii*, *Tinoporus baculatus*, *Heterostegina depressa*, *Calcarina hispida* (which, however, is one of the first organisms to disappear by solution), *Orbitolites complanata* and *O. marginalis*, and *Cycloclypeus Carpenteri*.

As regards the last named species, *C. Carpenteri*, it is interesting to note its occurrence at four localities round Funafuti, namely, Pava, Funamanu, Tutanga, and Fuafatu. It has a range in depth of 30-200 fathoms. At 50-60 fathoms both the megalospheric and the microspheric forms occur, form A greatly preponderating. At 80 fathoms form B (the microspheric or large discoid form) was most frequently dredged up alive by Prof. David.

*Notes on Foraminifera from the Reef-fragments,  
Funafuti.*

*CARPENTERIA BALANIFORMIS, Gray.*

*Carpenteria balaniformis*, Gray, 1858, Proc. Zool. Soc. Lond. vol. xxvi. p. 269, figs. 1-4.

*C. balaniformis*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. p. 13, pl. 4. figs. 1, 2.

Other deep-sea corals with numerous attached specimens of *C. balaniformis* have been sent on in further collections since the first paper on Funafuti Foraminifera was written. One of the corals came from 240 fathoms off Pava I., and is the deepest sample obtained from the reef. This specimen bears no less than 31 individuals of the above species distributed over the surface. A curious example of fusion between two shells also occurs, which points to the ability which this genus may possess of forming colonies and large masses of almost indefinite size, providing the growing test is not broken up by predatory fishes or by mechanical means.

## CARPENTERIA RHAPHIDODENDRON, Möbius. (Pl. 35. fig. 2.)

? *Polytremma brunnescens*, J. D. Dana, 1849, U.S. Exploring Exped., Atlas Zoophytes, p. 707, pl. 61. fig. 3.

*Rhaphidodendron album*, Möbius, 1876, Tageblatt der 49 Versammlung deutscher Naturforscher und Aerzte in Hamburg, p. 115.

*Carpenteria rhaphidodendron*, Möbius, 1880, Beiträge zur Meeresfauna der Insel Mauritius und der Seychellen, Berlin, p. 81, pl. v. figs. 6-10, pl. vi. fig. 1-6.

It is possible that the specimen which Dana described as "pale brownish, thick incrusting, cavernous, surface gibbous, lacerate and very irregular," is a young specimen of the above species. Since the full-grown form has been so admirably figured and described by Möbius from Mauritius, it is unnecessary to further disturb the nomenclature by substituting Dana's name.

This species is very much in evidence in certain parts of the core obtained from Funafuti, where it sometimes constitutes thick layers between the ordinary foraminiferal sand and reef-rock. More often, however, it is represented only by fragments broken down to a more or less uniform size, as though by the agency of browsing animals.

*C. rhaphidodendron* appears to be most at home in depths between 63 and 80 fathoms.

## CARPENTERIA SERIALIS, sp. nov. (Pl. 35. fig. 3.)

Test hyaline, somewhat glassy or polished in texture, consisting of more or less numerous chambers sometimes shaped like a calabash or water-pot with a distinctly spouted aperture placed a little eccentrically, at others of a combination of flask and long cylindrical spout. The apertures, in fresh specimen, armed with sponge-spicules. Chambers arranged in roughly linear fashion or in a meandering series. Adherent to reef-rock. Diameter of the chambers at their base 1-2.25 millim. Diameter of aperture about .3 millim. This organism appears at first sight to bear a deceptive resemblance to certain forms of Polyzoa.

Found at Tutanga, 200 fathoms. Frequent.



*POLYTREMA PLANUM*, Carter. (Pl. 35. figs. 2 & 4.)

*Polytrema planum*, Carter, 1876, Ann. & Mag. Nat. Hist. ser. 4, vol. xvii. pp. 211, 212, pl. xiii. figs. 18, 19.

*Gypsina melobesoides*, Carter, 1877, Ann. & Mag. Nat. Hist. ser. 4, vol. xx. p. 172.

*Polytrema miniaceum*, var. *involuta*, Chapman, 1900, Journ. Linn. Soc., Zool. vol. xxviii. pp. 17, 18, pl. 2. fig. 3, and text-figure 2.

*P. planum*, Carter, Chapman, 1901, Ann. & Mag. Nat. Hist. ser. 7, vol. vii. pp. 82, 83.

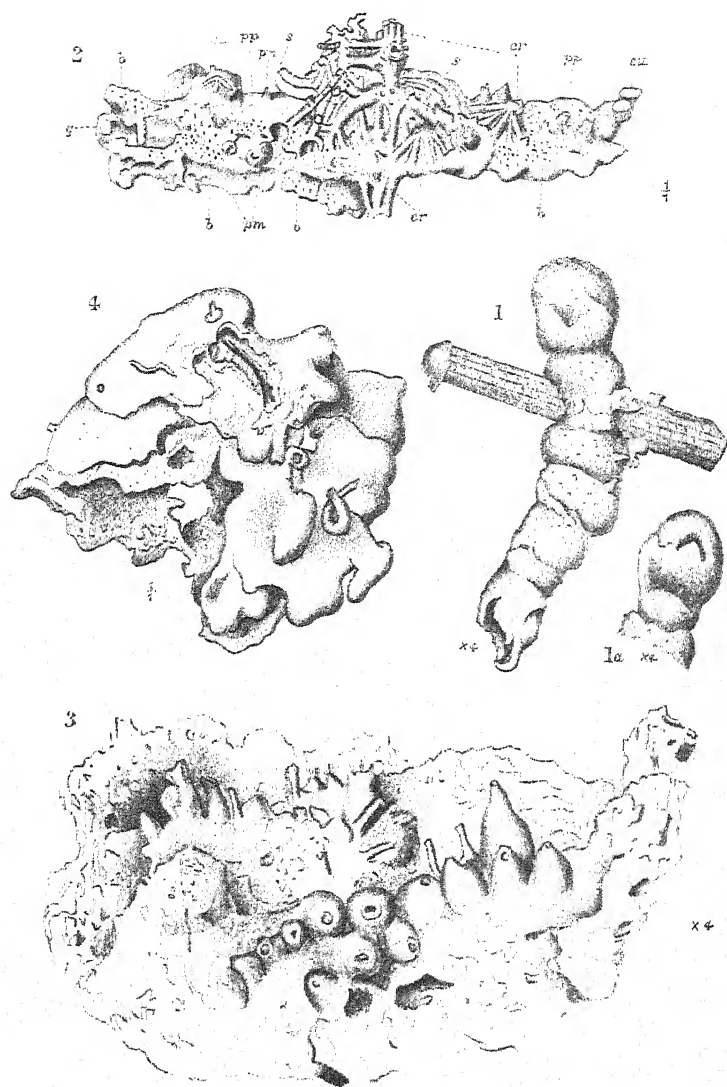
*P. planum*, Chapman, 1901, Journ. Linn. Soc., Zool. vol. xxviii. pp. 201, 202, pl. 20. figs. 6, 7.

This freely-growing foraminifer produces extraordinarily large masses of calcareous rock at Funafuti. At first sight they were thought to be calcareous algæ, for their habit of growth is very similar to encrusting forms of *Lithothamnion* and *Lithophyllum*. A microscope-section of the organism, however, at once reveals its relationship with *Polytrema* and *Gypsina*. It is extremely difficult to decide from an examination of the external surface whether the specimens are foraminifera or algæ, unless one has a special knowledge of the minute differences met with in the respective groups.

It is not uncommon to find this organism forming an encrusting mass of about 5 centimetres square. One example from Tutanga (60-100 fathoms) measures about  $7 \times 5$  centimetres. Another piece of calcareous rock, composed almost entirely of laminar growths of *P. planum*, has a measurement of  $13 \times 5 \times 4$  centimetres.

As regards the depths at which this peculiarly interesting foraminifer is found, the limits of its best development are from about 80 to 200 fathoms.

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F. Chapman ad nat. del.  
M. F. Parker lith.

Parsons & West insp.

REEF-BUILDING FORAMINIFERA FROM FUNAFUTI.



V. A SUMMARY of the FORAMINIFERA found at DEPTHS from 16-200 FATHOMS ROUND FUNAFUTI, in dredgings made by Messrs. HALLIGAN and FINCKH.

In this table the results of the detailed examination of the sands obtained during the latter part of the work of the Expedition, in 1898, are given.

The columns are arranged in order of depth, the localities occupying a secondary place. The reason adduced for this is that in the case of Foraminifera from the loose sands found either in shallow or fairly deep water the temperature seems to be a more important factor than local surroundings; whereas in the case of the reef samples the organisms are largely dependent upon environment.

The dredgings include, besides Foraminifera, the following organisms—Calcareous Algæ (*Halimeda*, *Corallina*, *Lithothamnion*, and other genera), Calcisponges and loose spicules, Alcyonarian spicules, Serpulæ and boring Annelides, Polyzoa, Ascidian spicules, Lamellibranchiate shells, Heteropods, Gasteropods, Pteropods, Echinodermal plates and spines, Ostracoda (chiefly *Bairdia* and *Loxococoncha*) and other Crustacea.

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In the annexed synopsis of species from the Funafuti Atoll, for the sake of uniformity of treatment and in order to enable a comparison with the Synopsis given in my former paper (pp. 206-209 of the present volume), the following significations are used:—v.r. = very rare, r. = rare, f. = frequent, c. = common, v.c. = very common.







78.	"	<i>concaea</i> , Karst.	..	..	..	..	v.F.
79.	"	<i>crispata</i> , Brady	..	..	..	..	F.
80.	"	<i>transversaria</i> , Brady	..	..	..	..	v.F.
81.	"	<i>convexa</i> , d'Orb.	..	..	..	..	f.
82.	"	<i>trochus</i> , d'Orb.	..	..	..	..	v.F.
83.	"	<i>gracilis</i> , d'Orb.	..	..	..	..	..
84.	"	<i>aquilinus</i> , d'Orb.	..	..	..	..	..
85.	"	" <i>porrecta</i> , Brady	..	..	..	..	..
86.	"	<i>sagittula</i> , DeRance	..	..	..	..	..
87.	"	" var. <i>fistulosa</i> , Brady	..	..	..	..	..
88.	"	<i>siphonifera</i> , Brady	..	..	..	..	..
89.	"	<i>rugosa</i> (Reuss)	..	..	..	..	..
90.	"	<i>Venerulina spinulosa</i> , Reuss	..	..	..	..	..
91.	"	<i>Gaudryina rugosa</i> , d'Orb.	..	..	..	..	..
92.	"	<i>attenuata</i> , sp. nov.	..	..	..	..	..
93.	"	<i>rotunda</i> , sp. nov.	..	..	..	..	..
94.	"	<i>Valvulina fusca</i> (Wal.)	..	..	..	..	..
95.	"	<i>Chamalina angularis</i> , d'Orb.	..	..	..	..	..
96.	"	" <i>cuneatus</i> , d'Orb.	..	..	..	..	..
97.	"	<i>cyathifera</i> , Hantken	..	..	..	..	..
98.	"	<i>Bulinina elegans</i> , d'Orb., var. <i>cavilis</i> , Brady	..	..	..	..	..
99.	"	" <i>elegantissima</i> , d'Orb.	..	..	..	..	..
100.	"	<i>suberosa</i> , Brady	..	..	..	..	..
101.	"	<i>convoluta</i> , Will.	..	..	..	..	..
102.	"	<i>Virgalina subspumosa</i> , Egger	..	..	..	..	..
103.	"	" <i>Schweizeriana</i> , Oz.	..	..	..	..	..
104.	"	<i>Bifurina linbata</i> (Brady)	..	..	..	..	..
105.	"	<i>Boklevina textularoides</i> , Reuss	..	..	..	..	..
106.	"	" <i>punctata</i> , d'Orb.	..	..	..	..	..
107.	"	" <i>porrecta</i> , Brady	..	..	..	..	..
108.	"	" <i>dilatata</i> , Reuss	..	..	..	..	..
109.	"	" <i>robusta</i> , Brady	..	..	..	..	..
110.	"	" <i>arenosa</i> , Chap.	..	..	..	..	..















*Note on New Species from the Sands of the Reef-slope.*

*SPIROLOCULINA PARVULA*, sp. nov. (Pl. 36. fig. 5.)

Test ovate, complanate, extremities produced. Oral extremity usually terminating in a tubular prolongation, with an everted rim. Segments few and broad, marked by salient sutural edges; surface of segments more or less excavated. Length .35 mm.

Off Tutanga, 200 fathoms; frequent.

*Affinities*.—This form seems to be intermediate between Brady's *Spiroloculina limbata* var.\* and Terquem's *S. impressa*†. From the former of these it differs chiefly in its smaller size and spouted orifice, and from the latter in having a more circularly ovate outline.

*OPHTHALMIDIUM CORNU*, sp. nov. (Pl. 36. fig. 6.)

Test ovate, compressed; the early spiral tube small and neatly coiled; the later Spiroloculine segments large and few in number, and partly concealing the spiral portion of the shell. The later segments have a thin peripheral flange, as in *O. inconstans*. Aperture trumpet-shaped and opening towards one side of the test. Length of test .5 mm. or less.

Off Tutanga, 50-60 fathoms; rare.

*HAPLOPHRAGMIUM CASSIS* (Parker). (Pl. 36. fig. 8.)

*Lituola cassis*, Parker, 1870 (in Dawson's paper), *Canad. Nat. n. s.* vol. v. p. 177; p. 180, fig. 3.

*Haplophragmium cassis* (Parker), Brady, 1884, *Rep. Chall.* vol. ix. p. 304, pl. xxxiii. figs. 17-19.

The tendency in our specimens is for the oblique chambers to be subdivided, giving an appearance like that of *Cassidulina* to the test. The species is, however, extremely variable. Until Millett recorded this species from the Malay Archipelago, it appeared to be confined to the colder areas of northern seas.

W. of Tutanga, 35 fathoms; very rare.

*HAPLOPHRAGMIUM TESSELTUM*, sp. nov. (Pl. 36. fig. 9.)

Test moderately thin, compressed, the spiral commencement subcircular in outline, septation very obscure; later chambers few, constricted at the septal lines, and arranged in an irregular rectilineal manner. Surface of shell marked by polygonal areolæ. Length of test 1.3 mm.

\* *Rep. Chall.* 1884, vol. ix. p. 151, pl. x. figs. 1, 2.

† *Mém. Soc. Géol. France*, sér. 3, 1878, vol. i. p. 53, pl. x. fig. 8.

*Affinities*.—The nearest allied form to this species is *H. calcareum*, Brady\*, but the latter has the initial portion of the test more inflated, and is composed of irregular calcareous particles. The test in *H. tessellatum* is formed of angular chips cemented by a harder substance which stands out in relief above the fragments themselves.

Off Funamanu, 50 fathoms; very rare.

*GAUDRYINA ATTENUATA*, sp. nov. (Pl. 36. fig. 10.)

Test elongate, somewhat sinuate or twisted; commencing with a sharply triangular series of chambers arranged triserially, followed by an irregular textularian arrangement, and finally by two or three pairs of subglobular chambers. Length of test about 1.3 mm.

*Affinities*.—This species is not unlike *G. baccata*, Schwager†, but differs in having an acutely angular commencement, and the test is much more attenuate.

W. of Tutanga, 35 fathoms; rare.

*GAUDRYINA ROTUNDA*, sp. nov. (Pl. 36. figs. 11 a-c.)

Test short and stout or subrotund; the earlier triserial chambers are subglobose, and these are quickly followed by subglobose chambers slightly flattened laterally and arranged in a biserial manner. Aperture a crescentic textularian slit. Shell-wall arenaceous, somewhat coarse in texture and whitish. Length of test about 2.2 mm.; greatest width 2 mm.

At a first glance this species might be taken for *Verneuilina propinqua*, Brady‡, which, however, is distinctly biserial in the later part of the shell.

This species was found only at one locality, and the specimens in point of size are all much alike.

Off Tutanga, 200 fathoms; frequent.

*BIFARINA LIMBATA* (Brady). (Pl. 36. fig. 12.)

The general tendency of this species as it occurs at Funafuti is, when fully developed, towards the dimorphous genus *Bifarina*. It has the later chambers arranged in a uniserial manner, and they are connected internally by a siphonate tube, terminating in a phialine aperture. The general arrangement of the test in our specimens is less distinctly textularian than in the

\* Rep. Chall. 1884, vol. ix. p. 302, pl. xxxiii. figs. 5-12.

† Novara-Exped., Geol. Theil, vol. ii. 1866, p. 200, pl. iv. fig. 12.

‡ Rep. Chall. 1884, vol. ix. p. 387, pl. xlvii. figs. 8-14.



HETEROSTEGINA DEPRESSA, *d'Orbigny*.

This species occurs practically in every dredging round Funafuti. It is usually the megalospheric form (A) which is found in such abundance. Form B has only been found at one locality at "To," S. of Fuafatu, 60 fathoms. Since writing the note on this species from Funafuti previously published \*, the author has measured the megalosphere and the microsphere with the following result:—

Form A.—Specimen from N. of Pava, 36 fathoms; megalospheric chamber with diameter of 125  $\mu$ .

Form B.—Specimen from S. of Fuafatu, 60 fathoms: microsphere chamber with diameter of 65  $\mu$ .

CYCLOCYPEUS CARPENTERI, *Brady*.

In the former paper, above mentioned, the presumably numerous and half-grown microspheric forms of *C. Carpenteri* there referred to have on further investigation proved to be variant forms of the megalospheric type. My attention was kindly drawn to this by Mr. J. J. Lister, who noticed the exceptionally large measurements quoted for the microspheric form of the species. Since then, on further examination, it appears that the megalosphere is not constant in size, some specimens having the primordial chamber much smaller than others.

The only undoubted example of a microspheric shell which the writer has been able to obtain amongst the numerous specimens from Funafuti is that which has already been figured in section in the former paper † as *Cyclocypeus* with a *Heterostegine* commencement. The section, on careful examination, proves to have been cut, most fortunately, quite accurately through the median plane; and the interesting spiral development of the earlier chambers may be quite typical of all microspheric forms of the species (see *l. c.* fig. 2). The writer looks forward to corroboration on this point. This spiral commencement may be compared with parallel forms in the porcellaneous group, as in *Orbiculina* and *Orbitolites marginalis*.

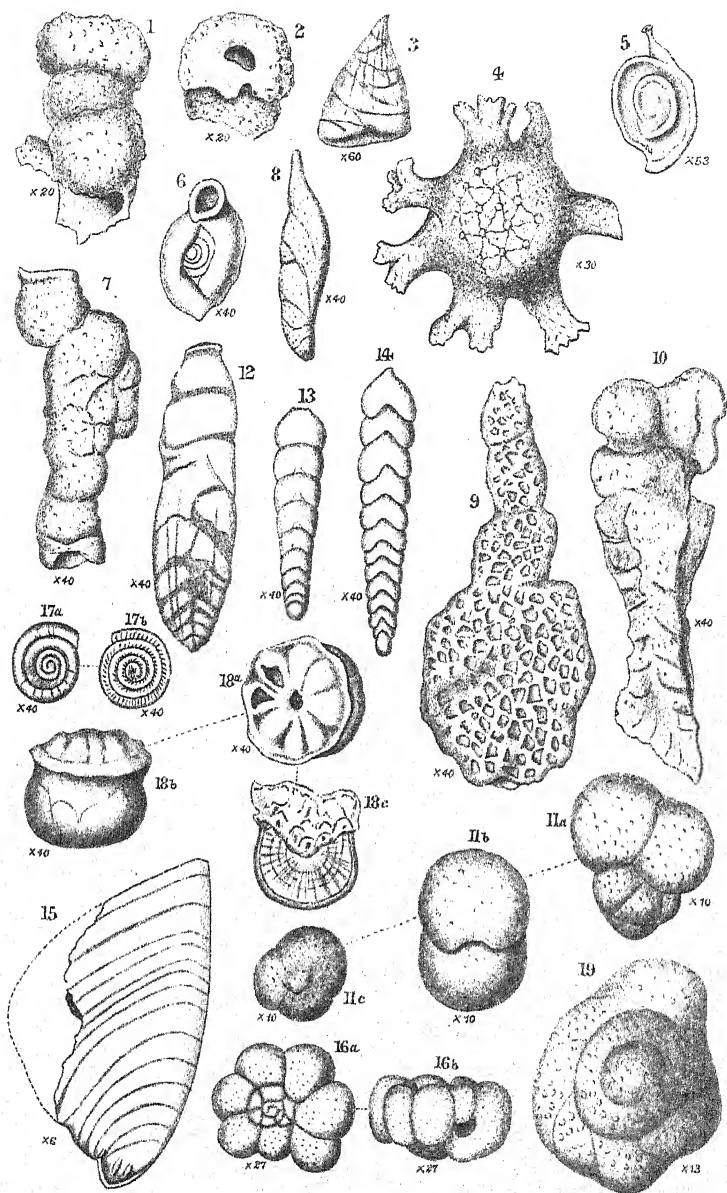
The measurements of the megalosphere and microsphere for this species give the following results:—

Form A, megalospheric chamber with the diameter of 260  $\times$  240  $\mu$  (average example).

Form B, microspheric chamber with a diameter of 40  $\mu$ .

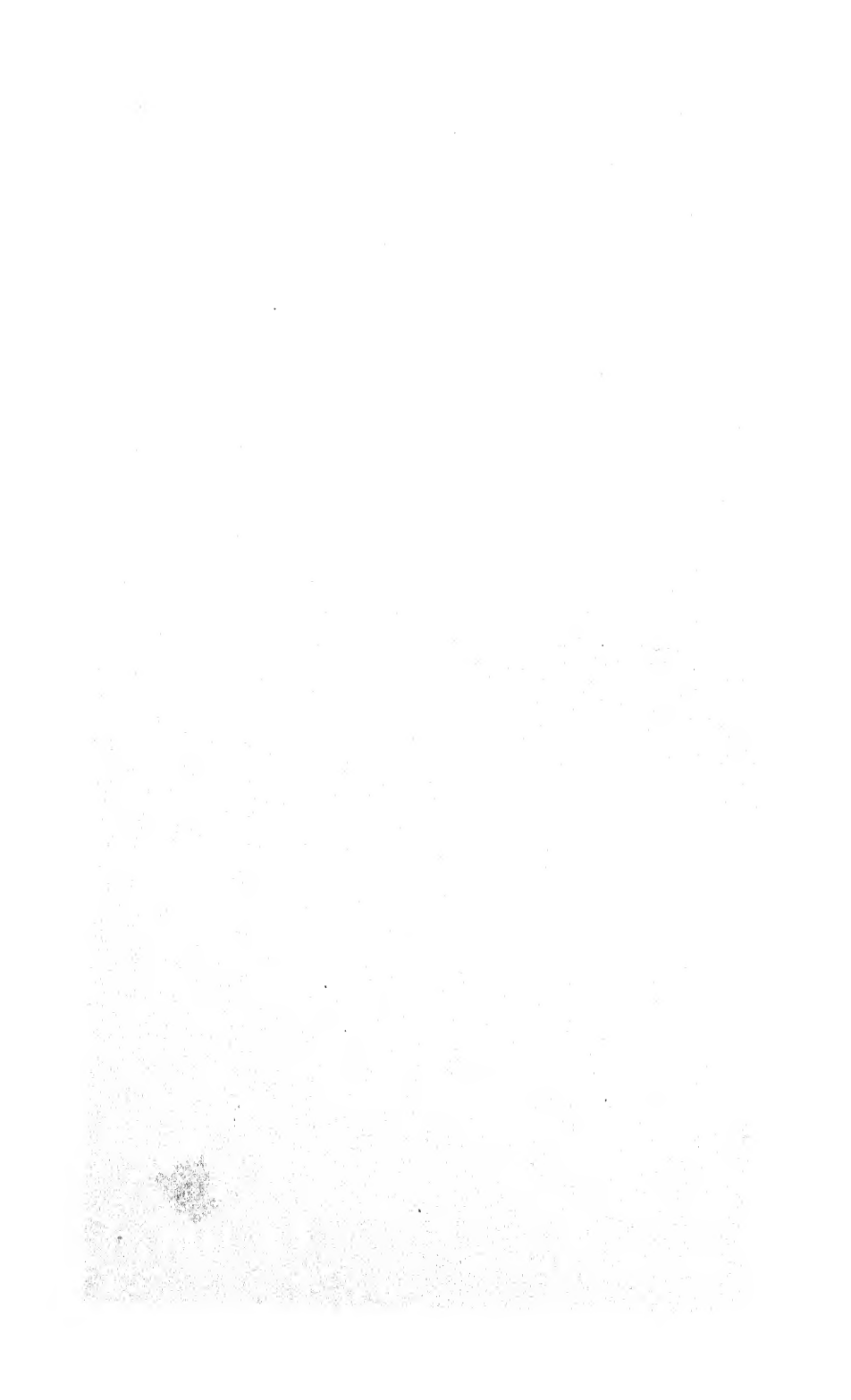
\* Journ. Linn. Soc., Zool. vol. xxviii. p. 19.

† Ibid. p. 27, pl. iii. fig. 2.



F. Chapman ad nat. del.  
M.F. Parker lith.

Parker & West trap.



In addition to the 273 species and varieties above recorded, from the sands of the reef-slopes, the lists previously given, exclusive of the lagoon fauna, include 19 other forms, namely:—

*Nubecularia Bradyi*, *N. lacunensis*, *Biloculina irregularis*, *Spiroloculina canaliculata*, *Miliolina trigonula*, *M. Boueana*, *M. tricarinata* var. *Bertheliniana*, *Peneroplis* (*Monalysidium*) *cylindracea*, *Orbitolites complanata* var. *plicata*, *Verneuilina Davidiana*, *Discorbina tabernacularis*, *D. acuminata*, *Planorbulina acervalis*, *P. retinaculata*, *Carpenteria serialis*, *Calcarina Spengleri*, *C. hispida* var. *pulchella*, *Tinoporus baculatus* var. *florescens*, and *Polystomella striatopunctata*; thus bringing the total number to 292 species and varieties.

#### VI. NOTES on the DISTRIBUTION of some of the SPECIES of FORAMINIFERA from the REEF-SLOPE at FUNAFUTI.

The shallow-water deposits of modern coral-reef areas are generally believed to contain, as a rule, few species of Foraminifera, but what is lacking in variety is usually compensated for by quantity. The exceptions to this rule are the faunas recorded from Raine's Islet, Torres Straits, and the present one from Funafuti. At the first-named locality the total number of Foraminifera found by Brady was 255 species and varieties. The number now recorded from the outer reef and beach of Funafuti amounts to 292. At a casual glance, however, the beach-sands, even at Funafuti, are apparently composed of about half a dozen forms, and it is only by a detailed examination of samples taken in the locality from various places and depths that we have been enabled to record such a rich foraminiferal fauna.

It will be as well to consider the distribution of certain of the Foraminifera met with to the present time on the reef-slope of Funafuti under three heads:—the encrusting or reef-forming foraminifera; the bottom-living forms; and the pelagic species.

##### *The Encrusting Foraminifera.*

Those which call for special notice on account of their profuse growth are *Carpenteria raphidodendron* and *Polytrema planum*.

The depth at which *C. raphidodendron* finds its habitat is very clear from the records obtained, for it was frequently found in two localities at depths of 60 and 80 fathoms. Fragments were also recorded from a sample at 180 fathoms; a doubtful

occurrence at 240 fathoms is recorded. The massive *Polytrem planum* is found at almost all depths from shallow water to 200 fathoms, but it appears to attain its highest development at a depth of 80 fathoms. It is well distributed round the atoll.

*The Bottom-living or Benthos species of Foraminifera.*

The species likely to be useful in affording data as to depth and other conditions of existence, in conjunction with the information derived from an examination of the consolidated or sandy material from the deep boring in the atoll, seem to be the following:—

*Orbitolites marginalis*.—This species occurs in its highest development and most frequently in the beach-sands, where at one place it is excessively common. It is also abundant at depths of 32 and 36 fathoms. At other depths it is found in less profusion, and is rare at 200 fathoms.

*O. duplex*.—Although this is a common species in certain parts of the core from the main boring, it is by no means so in the dredgings, for it never occurs in larger numbers than three or four in any of the samples. It is found as far down as 200 fathoms, but is very rare at that depth.

*O. complanata*.—This is recorded from three samples of beach-sands, and occurs at two of them in abundance. It is somewhat rare at the various levels down to 200 fathoms, excepting in one spot at a depth of 60 fathoms, where it is common.

*Alveolina Boscii*.—This is another species which occurs in the deep-boring at certain places with some frequency, but which is only found in two places on the reef-slope, at 36 fathoms and 50–60 fathoms. A solitary specimen was noticed adhering to a reef-fragment from the shore. With regard both to this species and *Orbitolites duplex*, either the conditions at the present time and those of the past when the atoll was being built up differ, or, as is very probable, the species noted are extremely local in their distribution, and thus have been overlooked by the collector.

*Calcarina hispida* is very common in certain of the beach-sands, and is also fairly abundant at depths of 35, 36, and 60 fathoms on the reef-slope.

*Amphistegina Lessoni* and *Heterostegina depressa* occur at all depths at Funafuti down to 200 fathoms. Both species are at their best, in point of size, at about 36 fathoms.

*Cycloclypeus Carpenteri*.—This species is recorded as occurring

in comparative abundance from 50 to 200 fathoms. At a depth of 50-60 fathoms it appears to be in greatest profusion, associated with form B.

### *The Pelagic Foraminifera.*

On reference to the foregoing Distribution Table it will be noticed that the pelagic species found in the dredgings almost uniformly increase in number according to the depth of water, and concurrently as the open water of the ocean is approached. This is exactly what might be expected, since the sides of the atoll present an even slope, and there are no other islands in the vicinity. An exception to this rule is *Globigerina conglobata*, which is frequently found in the shallow sands round the atoll. The thickness of the test in this species is a striking feature, and is comparable with other pelagic forms originally thin-shelled, but which become possessed of a thickened shell-wall on assuming the conditions of life in common with other bottom-living forms.

The list of pelagic species occurring at Funafuti is as follows:—*Globigerina bulloides*, *G. bulloides* var. *triloba*, *G. rubra*, *G. Dutertrei*, *G. pachyderma*, *G. suberetacea*, *G. æquilateralis*, *G. conglobata*, *G. sacculifera*, *G. digitata*, *G. dubia*, *Orbulina universa*, *Cuudenia nitida*, *Sphæroidina dehiscens*, *Pullenia obliquiloculata*, *Cymbalopora* (*Tretomphalus*) *bulloides*, *Pulvinulina Menardii*, *P. tumida*, and *P. canariensis*.

The pelagic species noted from the beach-sands are *Globigerina sacculifera* and *Cymbalopora* (*Tretomphalus*) *bulloides*; whilst from the shallowest dredgings of the lagoon on the open side small specimens of *Globigerina bulloides* and its variety *triloba* have occurred with some frequency.

In bringing to a conclusion the main results on the Foraminifera of the dredged material down to 200 fathoms from Funafuti, it gives me much pleasure to reiterate my sincere thanks to those who have so carefully collected the material upon which this examination has been based; as well as to Prof. Judd, C.B., for facilities very kindly afforded for studying the collections at the Royal College of Science. My thanks are also due to my wife for assistance in elaborating this work, and to Mr. E. J. Tallin for his help in the selection of specimens.

## EXPLANATION OF THE PLATES.

## PLATE 35.

- Fig. 1. *Haddonia torresiensis*, Chapman. A specimen broken off main attachment, and growing over an echinid spine\*. Funamunu (Beacon I.), 150 fathoms.
- Fig. 2. Reef-fragment drawn the natural size, from Funamunu, 80 fathoms, chiefly formed of *Carpenteria raphidodendron*, Möbius. The letters signify:—
- c.r. *Carpenteria raphidodendron*.
  - b. Basal portion of the same.
  - c.u. *Carpenteria utricularis*.
  - p.m. *Polytrema miniaceum*.
  - p.p. *Polytrema planum*.
  - g. Gorgoniid stem.
  - s. *Serpula*.
- Fig. 3. *Carpenteria serialis*, sp. nov. A colony of serial chambers, growing between masses of *Polytrema planum*. W. of Tutanga, 200 fathoms.  $\times 4$ .
- Fig. 4. A large fragment of the reef-former *Polytrema planum*, Carter. The specimen shows a bivalve shell nearly covered up, and also attached specimens of *Polytrema miniaceum* and a *Serpula*. Off Tutanga, 135 fathoms. Natural size.

## PLATE 36.

- Fig. 1. *Haddonia minor*, sp. nov. Lateral aspect. Dredged off Tutanga, 50–60 fathoms.  $\times 20$ .
2. *H. minor*, sp. nov. Oral aspect. Tutanga, 50–60 fathoms.  $\times 20$ .
3. *Discorbina acuminata*, sp. nov. Lateral aspect. Shore-sand, Avalau Islet.  $\times 60$ .
4. *Tinoporus baculatus* (Montf.), var. *florescens*, nov. Lateral aspect. Shore-sand, Avalau Islet.  $\times 30$ .
5. *Spiroculina parvula*, sp. nov. Lateral aspect. Off Tutanga, 200 fathoms.  $\times 40$ .
6. *Ophthalmidium cornu*, sp. nov. Lateral aspect. Off Tutanga, 50–60 fathoms.  $\times 40$ .
7. *Haddonia minor*, sp. nov. Lateral aspect of a small irregular specimen. Off Tutanga, 50–60 fathoms.  $\times 40$ .
8. *Haplophragmium cassis* (Parker). Lateral aspect. Dredged W. of Tutanga, 35 fathoms.  $\times 40$ .
9. *H. tessellatum*, sp. nov. Lateral aspect. Dredged off Funamunu, 50 fathoms.  $\times 40$ .
10. *Gaudryina attenuata*, sp. nov. Lateral aspect. Dredged W. of Tutanga, 35 fathoms.  $\times 40$ .
- Figs. 11 a–c. *G. rotunda*, sp. nov. 11 a, lateral aspect; 11 b, oral aspect; 11 c, aboral aspect. Off Tutanga, 200 fathoms.  $\times 10$ .

\* See Journ. Linn. Soc., Zool. vol. xxviii. (1900) p. 6, last paragraph.

- Fig. 12. *Bifarina limbata* (Brady). Lateral aspect. Off Tutanga, 200 fathoms.  $\times 40$ .
13. *Lingulina carinata*, d'Orbigny. Lateral aspect. Off Tutanga, 200 fathoms.  $\times 40$ .
14. *Fronicularia spathulata*, Brady. Lateral aspect. Off Tutanga, 200 fathoms.  $\times 40$ .
15. *Cristellaria mirabilis*, sp. nov. Lateral aspect. Off Tutanga, 200 fathoms.  $\times 5$ .
- Figs. 16 *a, b*. *Globigerina suberulacea*, sp. nov. 16 *a*, inferior aspect; 16 *b*, peripheral aspect. Off Tutanga, 200 fathoms.  $\times 20$ .
- Figs. 17 *a, b*. *Spirillina decorata*, Brady, var. *unilatera*, nov. 17 *a*, superior (smooth) surface; 17 *b*, inferior (ornate) surface. Off Tutanga, 200 fathoms.  $\times 40$ .
- Figs. 18 *a-c*. *Cymbalopora (Tretomphalus) inversa*, sp. nov. 18 *a*, basal aspect; 18 *b*, lateral aspect; 18 *c*, median section through the Cymbaloporoid shell and the inverted "brood-chamber," which in this species is thrown over the primordial series of chambers; the inflated chamber is usually filled with a secondary or ?organic calcareous deposit, showing radial and concentric structures as if formed of aragonite. W. of Tutanga, 35 fathoms.  $\times 40$ .
- Fig. 19. *Pulvinulina punctulata* (d'Orb.), var. *scabra*, nov. Superior aspect. Off Tutanga, 200 fathoms.  $\times 13$ .

### On some Ostracoda from Funafuti.

By FREDERICK CHAPMAN, A.L.S., F.R.M.S.

[Read 19th December, 1901.]

(PLATE 37.)

DURING the progress of the examination of the rich foraminiferal material from Funafuti which I have had the privilege of describing, many specimens of Ostracoda have been selected and mounted, with the view of furnishing material for a separate report. This collection of Ostracoda has been kindly placed in my hands by Prof. J. W. Judd, C.B., LL.D., F.R.S., for description, who has also given me facilities for working upon them, as time permitted, in the Geological Laboratory of the Royal College of Science.

The Ostracoda from Funafuti have been obtained from various sources during the work of the Expeditions for the purpose



of boring in the Atoll. They represent the recent deposits obtained by dredging outside the Atoll at moderate depths for the most part, but many specimens were also selected from the dredgings in the lagoon, the beach-sands, the deep-sea deposits (not yet fully worked out), and the sands from the atoll-boring. The data attached to the specimens of the latter samples, as regards depth, are probably of not much value, since there must be considerable admixture of loose material in the bore-hole during the process of boring.

The total number of species is 52, six of which are new. The commoner forms present many striking facts as to their variation at different depths and under dissimilar conditions.

A large number of the species enumerated here have been described from the various groups of islands in the Pacific by Dr. G. S. Brady, the remainder being known from widely scattered localities. The occurrence of the genus *Limnocythere* in the samples is noteworthy, on account of its freshwater habit.

The valves were for the greater part empty, or otherwise mounted for the examination of the animal or their appendages.

## SECTION I. PODOCOPA.

### Family CYPRIDIDÆ.

#### PONTOCYPRIS, *G. S. Brady*.

##### PONTOCYPRIS ? *FABA*, *Reuss*, sp.

*Bairdia faba*, Reuss, 1855, Ein Beitrag zur genaueren Kenntniss der Kreidegebilde Meklenburgs, Zeitschr. d. deutsch. Geol. Gesellsch. p. 278, pl. x. fig. 2.

*Pontocypris*? *faba*, Reuss sp., G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 37, pl. i. figs. 4 *a-d*.

Several valves were found in the material from Funafuti, generally comparable with those which show the greatest height of carapace in the 'Challenger' series.

From the first boring at Funafuti, near the surface (Sollas collection); lagoon dredgings, sample 18, 9 miles from the Mission Church, Funafuti (David coll.); beach-sand, Avalau Islet, Funafuti (Sollas coll.); dredgings W. of Tutanga, 200 fathoms (Halligan and Finckh).

*PONTOCYPRIS ATTENUATA, G. S. Brady.*

*Pontocypris attenuata*, G. S. Brady, 1868, Ann. Mag. Nat. Hist. ser. 4, vol. ii. p. 179, pl. iv. figs. 11-14; id. 1890, Trans. Roy. Soc. Edinb. vol. xxxv. p. 491, pl. i. figs. 3, 4.

In one instance only the valves from Funafuti show indications of a posterior spine; otherwise they resemble the most typical specimens. Dr. Brady has lately described this species from Nouná, and from the reef at Apia, Upolu.

At Funafuti this species was found in the beach-sand at Avalau Islet (Sollas coll.); in the lagoon dredgings, sample 18, 9 miles from the Mission Church,  $7\frac{1}{2}$  fathoms (David coll.); off Funamanu, 150 fathoms, and off Tutanga, 50-60 and 200 fathoms (David, Halligan and Finckh coll.).

*PONTOCYPRIS SICULA, G. S. Brady.*

*Pontocypris sicula*, G. S. Brady, 1890, Trans. Roy. Soc. Edinb. vol. xxxv. p. 492, pl. i. figs. 7, 8.

The type specimens were found in anchor-mud, at 4 fathoms, Sava-Sava, Fiji.

Characteristic valves were found at Funafuti in the beach-sand, Avalau Islet (Sollas coll.); and in dredgings, N. of Pava, 32 fathoms, and off Tutanga, 200 fathoms (David, Halligan and Finckh coll.).

*ARGILLÆCIA, G. O. Sars.**ARGILLÆCIA AFFINIS, sp. nov. (Pl. 37. figs. 1 a-c.)*

Carapace oblong, somewhat compressed, subpyriform; height less than half the length. In side view the anterior extremity obliquely rounded; posterior produced, with the ventral angle subacute. Dorsal margin slightly arched, or nearly straight, especially in the middle third, sloping sharply backward to the ventral angle. Ventral margin slightly sinuate, hollow in the centre. Edge view subovate, acuminate in front, rounded behind; width equal to the height. End view nearly circular. Shell-surface polished, and seen to be faintly pitted, when viewed with a high power. Length of carapace .66 mm.

This species is most nearly allied, in the form of the carapace, to *A. acuminata*, G. W. Müller\*. The specimen was not

\* Monogr. Ostracoda (Fauna des Golfes von Neapel), xxi. 1894, p. 261, pl. 12. figs. 1, 2.

preserved well enough to show any of the organization of the animal, and further specimens may show that it has something more than a relationship with Müller's species. Our specimen differs from the former in the greater lateral width of the carapace, and the more tumid posterior extremity. *A. affinis* differs from *A. eburnea*, Brady, in its more regularly ovate form.

From soundings made by H.M.S. 'Penguin' near Funafuti, lat.  $11^{\circ} 05' S.$ , long.  $178^{\circ} 40' E.$ ; Sample 2, *Globigerina*-ooze, 1489 fathoms.

### FAMILY BAIRDIDÆ.

#### MACROCYPRIIS, *G. S. Brady.*

##### MACROCYPRIIS DECORA, *G. S. Brady.*

*Macrocypris decora*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. part iii. p. 44, pl. i. figs. 3 *a-d*, and pl. vi. figs. 8 *a, b*.

Among other localities this species has lately been recorded from Nouméa, New Caledonia, and Taviuni, Fiji.

At Funafuti, *M. decora* was found in dredgings from N. of Pava Islet, at 32 and 36 fathoms; off Funamanu, at 150 fathoms, and off Tutanga at 50-60 and 200 fathoms (David, Halligan and Finckh coll.).

#### BAIRDIA, *M. Coy.*

##### BAIRDIA AMYGDALOIDES, *G. S. Brady.*

*Bairdia amygdaloides*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 54, pl. ix. figs. 5 *a-f*, pl. x. figs. 2 *a-e*.

Of the coral-reef species of *Bairdia* this is one of the most striking, on account of its graceful outlines. It is well-known in the Pacific area.

At Funafuti, *B. amygdaloides* was found in the following samples:—

In the sand from the 1st boring near the surface, in the 2nd boring at 70 ft. down, in the beach-sand from Avalau Islet, and from lagoon dredgings, Rocky Islet (Sollas coll.). In the dredgings across the lagoon, sample 2, 1 mile from the Mission Church,  $15\frac{1}{2}$  fathoms; sample 6, 3 miles from the Mission Ch., 21 fathoms; sample 7,  $3\frac{1}{2}$  miles, 24 fathoms; sample 18, 9 miles,  $7\frac{1}{2}$  fathoms (David coll.). In dredgings from N. of Pava Islet

at 32, 35, and 36 fathoms, from Funamanu at 50 and 150 fathoms, and from Tutanga, at 35, 50-60, and 200 fathoms (David, Halligan and Finckh coll.)

*BAIRDIA CROSSKEIANA*, G. S. Brady.

*Bairdia Crosskeiana*, G. S. Brady, 1880, Rep. Chall. Exp., Zool. pt. iii. p. 58, pl. ix. figs. 3 a-c.

Dr. Brady has lately noted the above species from Fiji and Samoa. It is the commonest and most widely distributed form of the Ostracoda from Funafuti; and its occurrence at such a depth as 1489 fathoms is very remarkable.

From sand of the 1st boring in the Atoll, near the surface, from the 2nd boring at 40 feet down, and at 70 feet down; from the beach-sand of Avalau Islet, the lagoon beach of Fuafala, and the dredging in the lagoon at Rocky Islet (Sollas coll.). From the dredgings across the lagoon, sample 1,  $\frac{1}{2}$  mile from the Mission Church, 10 fathoms; sample 2, 1 mile from the Mission Ch. at  $15\frac{1}{2}$  fathoms; sample 4, 2 miles from Mission Ch. at 23 fathoms; sample 6, 3 miles from Mission Ch. at 21 fathoms; sample 7,  $3\frac{1}{2}$  miles from Mission Ch. at 24 fathoms; sample 18, 9 miles from Mission Ch. at  $7\frac{1}{2}$  fathoms (David coll.). From dredgings north of Pava Islet at 32 and 36 fathoms; off Funamanu at 50 and 150 fathoms; S. of Fuafatu, 60 fathoms; off Tutanga at 35, 50-60, and 200 fathoms (David, Halligan and Finckh coll.). Also from the 'Penguin' soundings, Sample 2, *Globigerina*-ooze, 1489 fathoms.

*BAIRDIA WOODWARDIANA*, G. S. Brady.

*Bairdia Woodwardiana*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 57, pl. xi. figs. 1 a-c.

Previously recorded among other localities from Fiji, this species has been sparingly obtained in several of the Funafuti samples:—

From sand of the 1st boring in the Atoll, near the surface; from the 2nd boring at 70 ft. down; and from the beach-sand at Avalau Islet (Sollas coll.). Also in dredgings around the Atoll, N. of Pava, at 32 and 36 fathoms; off Funamanu at 150 fathoms; S. of Fuafatu, 60 fathoms, and off Tutanga at 35 and 200 fathoms (David, Halligan and Finckh coll.).

*BAIRDIA TENERA*, G. S. Brady.

*Bairdia tenera*, G. S. Brady, 1886, Journ. Linn. Soc. (Zool.), vol. xix. p. 304, pl. xxxix. figs. 13-15; id. 1895, Trans. Roy. Soc. Edinb. vol. xxxv. p. 493, pl. i. figs. 11, 12.

The original specimens of the above form were obtained from Ceylon, and Dr. Brady subsequently obtained others from Samoa. At Funafuti *B. tenera* occurred only in one dredging, off Tutanga at 200 fathoms.

*BAIRDIA SIMPLEX*, G. S. Brady.

*Bairdia simplex*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 51, pl. vii. figs. 1 a-d.

This was lately recorded by Dr. Brady from Taviuni, Fiji, between tide-marks. It occurs in one sample only at Funafuti, in the first boring in the Atoll, near the surface (Sollas coll.).

*BAIRDIA HIRSUTA*, G. S. Brady.

*Bairdia hirsuta*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 50, pl. viii. figs. 3 a-d.

Typical examples of this form were found in the lagoon dredgings at Funafuti (David coll.), as follows:—

Sample no. 10, 5 miles from the Mission Church, 20 fathoms; sample no. 14, 7 miles from the Mission Ch., 26 fathoms.

*BAIRDIA MILNE-EDWARDSII*, G. S. Brady.

*Bairdia Milne-Edwardsii*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 56, pl. x. figs. 4 a-g; id. 1890, Trans. Roy. Soc. Edinb. vol. xxxv. p. 494.

This form is rather difficult to separate from *B. foveolata*, and appears to bear out Dr. Brady's conclusion that they may be merely varieties of the same species. The dorsal area is generally more tumid in this form. It has been recorded, among other localities, from Nouméa, New Caledonia, from Fiji and Samoa.

At Funafuti it is a frequent and well-distributed form; occurring in the sand of the first boring near the surface; the beach-sand, Avalau Islet; the lagoon beach at Fuafala; and the lagoon dredgings, Rocky Islet (Sollas coll.). Also from the dredgings across the lagoon, sample no. 1,  $\frac{1}{2}$  mile from the Mission Church, 10 fathoms; sample no. 17,  $8\frac{1}{2}$  miles from the Mission Ch., 12 fathoms; sample no. 18, 9 miles from the Mission Ch.,  $7\frac{1}{2}$  fathoms; from Funamanu, 150 fathoms;

off Tutanga at 35, 50-60, and 200 fathoms; and S. of Fuafatu, 60 fathoms (David, Halligan and Finckh coll.).

*BAIRDIA FOVEOLATA*, G. S. Brady.

*Bairdia foveolata*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 55, pl. viii. figs. 1 *a-f*, figs. 2 *a-f*; id. 1890, Trans. R. Soc. Edinb. vol. xxxv. p. 493.

This widely distributed form, which has also been noted from New Caledonia, Fiji, and Samoa, was found in the following samples from Funafuti:—In the beach-sands at Fualopa Islet and Avalau Islet; from the lagoon beach at Fuafala; and in dredgings from the lagoon, Rocky Islet (Sollas coll.). In the samples from the dredgings across the lagoon, no. 1,  $\frac{1}{2}$  mile from the Mission Church, 10 fathoms; no. 2, 1 mile from Mission Ch.,  $15\frac{1}{2}$  fathoms; no. 4, 2 miles from Mission Ch., 23 fathoms; no. 17,  $8\frac{1}{2}$  miles from Mission Ch., 12 fathoms; no. 18, 9 miles from Mission Ch.,  $7\frac{1}{2}$  fathoms: in dredgings off Funamanu, 50 and 150 fathoms; off Tutanga, 35, 50-50, and 200 fathoms (David, Halligan and Finckh coll.).

*BAIRDIA ATTENUATA*, G. S. Brady.

*Bairdia attenuata*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 59, pl. xi. figs. 3 *a-e*.

The previously known localities for this species are Torres Straits at 155 fathoms, and off the reefs at Honolulu, 40 fathoms. At Funafuti it was found in the lagoon dredgings, Rocky Islet (Sollas coll.); and in the systematic dredgings across the lagoon, sample 1,  $\frac{1}{2}$  mile from the Mission Church, 10 fathoms; sample 18, 9 miles from Mission Ch.,  $7\frac{1}{2}$  fathoms; also off Tutanga, 200 fathoms (David, Halligan, and Finckh coll.).

*BAIRDIA VENTRICOSA*, G. S. Brady.

*Bairdia ventricosa*, G. S. Brady, 1890, Trans. R. Soc. Edinb. vol. xxxv. p. 494, pl. iv. figs. 17, 18.

This species was originally described from Nouméa, New Caledonia. Typical examples were found by the author in the beach-sand of Avalau Islet, Funafuti (Sollas coll.).

## Family CYTHERIDÆ.

## CYTHERE, Müller.

## CYTHERE ACUPUNCTATA, G. S. Brady.

*Cythere acupunctata*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 68, pl. xiv. figs. 1 a-h.

It is interesting to record this species from Funafuti, especially since it is so rare elsewhere, having been found previously at one locality only, in the Inland Sea, Japan, at 15 fathoms.

At Funafuti *C. acupunctata* occurs in the beach-sand, Fualopa; and in the lagoon dredgings, Rocky Islet, in some abundance (Sollas coll.). Also in dredgings N. of Pava Islet, 36 fathoms, and off Tutanga, 50-60 fathoms (David coll.).

## CYTHERE OBTUSALATA, G. S. Brady.

*Cythere obtusalata*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 91, pl. xii. figs. 1 a-c.

Two characteristic valves of this rare species were found at Funafuti. It has been previously recorded from Bass Straits and off the Admiralty Islands in shallow water. At Funafuti it was found in the beach-sand of Avalau Islet (Sollas coll.), and off Tutanga, at 200 fathoms (Halligan and Finckh coll.).

## CYTHERE PHYLLOIDES, sp. nov. (Pl. 37. figs. 3 a-c.)

Shell compressed, elongate; side view oblong, broader at the anterior end, narrowing somewhat to the posterior extremity; height a little more than one-half the length; anterior extremity well-rounded, posterior rounded and obliquely curved on the postero-dorsal margin; the postero-ventral margin with a few sharp denticulations; both the ventral and dorsal margins nearly straight; anterior margin with a broad flange; posterior margin steep and flanged. Seen from above, the carapace is subovate, and incurved in the middle, broad at the posterior extremity and slightly narrowing to the anterior. End view subcircular, broad at the ventral, compressed at the dorsal, margin. Surface of valves ornamented with two thin flexuous ribs which run nearly their length, and some disconnected oblique and transverse riblets; the intercostal area filled with fine reticulations. Length .9 mm.

This form seems to be related to *C. stolonifera*, G. S. Brady \*, but differs in the shape of the valve, which in the latter is oblong, with a much-produced infero-posteal extremity. The ornamentation is on the same general plan, but in *C. phylloides* it is much more delicate. The carapace of *C. phylloides* is much more tumid and rounded in section than that of *C. stolonifera*.

*C. phylloides* was found in Sample no. 3 of the 'Penguin' soundings round Funafuti—lat. 10° 12' 53" S.; long. 178° 52' E.; *Globigerina*-ooze, 2715 fathoms.

CYTHERE FORTIFICATA, G. S. Brady.

*Cythere fortificata*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 75, pl. xxi. figs. 1 a-d.

This species was originally recorded from the mid-Pacific at 420 fathoms. It occurred at Funafuti, off Tutanga, at 200 fathoms (Halligan and Finckh coll.).

CYTHERE PECTUNCULATA, sp. nov. (Pl. 37. figs. 2 a, b.)

Carapace subquadrate and elongate in side view, broad at the anterior and narrower at the posterior extremity; dorsal margin sinuous, ventral straight; anterior margin well-rounded and having a flanged border, the superior edge of which is excavated or toothed; posterior extremity produced below. Surface of valve ornamented with fine pittings arranged in radiating lines, and with a central tubercle and two others situated posteriorly, one near the ventral margin behind the middle third, the other near the dorsal margin close to the upper posterior angle. Height equal to more than half the length. Edge view subovate, with the tubercles very prominent. End view subtriangular. Length .5 mm.

In some respects this form resembles *C. lactea*, G. S. Brady †, but it is much neater, narrower at the posterior extremity, and the tubercles and pittings are more distinctly developed.

*C. pectunculata* was found in the beach-sand of Avalau Islet, Funafuti, frequent (Sollas coll.).

CYTHERE WYVILLE-THOMSONI, G. S. Brady.

*Cythere Wyville-Thomsoni*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 82, pl. xx. figs. 4 a-f.

This species is not unfrequent at Funafuti. It was found in

\* Rep. Chall. Exped., Zool. pt. iii. p. 89, pl. xxi. figs. 3 a-d.

† Ibid. p. 91, pl. xxii. figs. 1 a-d.



the beach-sands at Fualopa Islet, at Avalau Islet, and in the lagoon dredgings from Rocky Islet (Sollas coll.): also in the lagoon dredgings sample 18, 9 miles from the Mission Church, at  $7\frac{1}{2}$  fathoms (David coll.); and in dredgings off Tutanga at 290 fathoms (Halligan and Finckh coll.).

*CY THERE PRAVA*, *Baird*, sp.

*Cythereis prava*, Baird, 1850, Proc. Zool. Soc. pt. xviii. p. 254, pl. 18. figs. 13-15.

*Cythere prava* (Baird), G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 92, pl. xxii. figs. 4 a-f.

The specimens from Funafuti are not very typical, but are apparently immature. In some points they resemble *Cythere pectunculata*, sp. nov., especially in the strong tubercles seen on the surface of the valves. Dr. Brady reports it as common among the South Sea Islands.

*C. prava* was found at Funafuti in the samples of sand from the 1st boring in the Atoll, near the surface; and in the beach-sands of Fualopa and Avalau Islets (Sollas coll.).

*CY THERE DELTOIDES*, *G. S. Brady*.

*Cythere deltoides*, G. S. Brady, 1890, Trans. R. Soc. Edin. vol. xxxv. p. 501, pl. ii. figs. 17, 18.

This species, which was originally described from specimens obtained by Dr. Brady from New Caledonia and Samoa, was found at one locality only at Funafuti, off Funamannu, 50 fathoms. The Funafuti specimen is typical but small, and is probably a young example.

*CY THERE CAUDATA*, *G. S. Brady*.

*Cythere caudata*, G. S. Brady, 1890, Trans. R. Soc. Edinb. vol. xxxv. p. 499, pl. ii. figs. 10, 11.

Previously recorded from Fiji. It is fairly common in the lagoon dredgings, Rocky Islet, Funafuti (Sollas coll.).

*CY THERE LACTEA*, *G. S. Brady*.

*Cythere lactea*, G. S. Brady, 1895, Trans. Zool. Soc. vol. v. p. 377, pl. lx. figs. 3 a-c.

This species was found at one locality only at Funafuti, in the lagoon dredgings from Rocky Islet.

LIMNICY THERE, *G. S. Brady.*LIMNICY THERE FIJIENSIS, *G. S. Brady.*

*Limnicythere fijiensis*, *G. S. Brady*, 1890, *Trans. R. Soc. Edinb.* vol. xxxv. p. 505, pl. ii. figs. 33, 34.

This form, which was first described from Fiji, was regarded by Dr. Brady as probably having been washed down into the tidal pools from fresh water. It is fairly common in the beach-sand of Avalau Islet, Funafuti (Sollas coll.).

KRITHE, *Brady, Crosskey, & Robertson.*KRITHE TUMIDA, *G. S. Brady.*

*Krithe tumida*, *G. S. Brady*, 1880, *Rep. Chall. Exped., Zool.* pt. iii. p. 115, pl. xxvii. figs. 4 a-d.

A single valve of this deep-water form was found in sample 2 of the 'Penguin' Soundings, 1489 fathoms.

KRITHE PRODUCTA, *G. S. Brady.*

*Krithe producta*, *G. S. Brady*, 1880, *Rep. Chall. Exped., Zool.* pt. iii. p. 114, pl. xxvii. figs. 1 a-j.

Typical specimens of this form were found in the 'Penguin' Soundings—Sample 2, 1489 fathoms; Sample 3, 2715 fathoms; and Sample 19, 1995 fathoms.

LOXOCONCHA, *G. O. Sars.*LOXOCONCHA ALATA, *G. S. Brady.*

*Loxoconcha alata*, *G. S. Brady*, 1868, *Ann. Mag. Nat. Hist.* ser. 4, vol. ii. p. 223, pl. xiv. figs. 8-13.

Previously recorded localities for this species are Honolulu, Mauritius, New Caledonia, and Fiji. It is usually an abundant form where found, and this is especially the case at Funafuti. It was found in the beach-sands of Fualopa and Avalau, and in the lagoon dredgings at Rocky Islet (Sollas coll.). From the soundings across the lagoon, sample 1,  $\frac{1}{2}$  mile from the Mission Church, 10 fathoms; sample 18, 9 miles,  $7\frac{1}{2}$  fathoms; also from dredgings N. of Pava, 32 fathoms; W. of Tutanga, 35 and 50-60 fathoms (David coll.).

LOXOCONCHA AUSTRALIS, *G. S. Brady.*

*Loxoconcha australis*, *G. S. Brady*, 1880, *Rep. Chall. Exped., Zool.* pt. iii. p. 119, pl. xxviii. figs. 5 a-f, and pl. xxix. figs. 3 a-d.

Previously known localities for this species are Port Jackson, Australia, Booby Island, and New Caledonia. Typical valves were found at Funafuti in the lagoon dredgings off Rocky Islet (Sollas coll.); and in the samples from the lagoon, No. 1,  $\frac{1}{2}$  mile from the Mission Church, 10 fathoms (David coll.).

*LOXOCOCONCHA TUMIDA*, sp. nov. (Pl. 37. figs. 5 a-c.)

Carapace seen from the side subovate, rounded, highest behind the middle; height equal to two-thirds the length; anterior extremity broad and well rounded; posterior end obliquely rounded on the dorsal angle and produced into a beak-like process; dorsal margin boldly arched, ventral slightly sinuous. Edge view subrectangular, sloping steeply towards the anterior margin, but somewhat square posteriorly. End view almost circular. Shell-surface smooth. Length .5 mm.

In some respects this form resembles *L. honoluluensis*\*, but is more tumid, and the surface is not relieved by pittings.

From the beach-sand, Avalau Islet, Funafuti (Sollas coll.).

*XESTOLEBERIS*, *G. O. Sars.*

*XESTOLEBERIS GRANULOSA*, *G. S. Brady.*

*Xestoleberis granulosa*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 125, pl. xxx. figs. 5 a-d.

This species, which is also known from New Caledonia among other localities, occurs with some frequency at Funafuti. It is essentially a shallow-water form, and was found in the beach-sand of Fualopa Islet and the lagoon dredgings, Rocky Islet (Sollas coll.). Also from the soundings across the lagoon, sample 17,  $8\frac{1}{2}$  miles from the Mission Church, 12 fathoms, and sample 18, 9 miles from the Mission Church,  $7\frac{1}{2}$  fathoms (David coll.).

*XESTOLEBERIS SETIGERA*, *G. S. Brady.*

*Xestoleberis setigera*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 125, pl. xxxi. figs. 2 a-d and figs. 3 a-c.

This form, which closely resembles *X. depressa*, G. O. Sars, is not common at Funafuti, although well distributed. It occurs in the beach-sand of Avalau, the sand from the lagoon beach at

\* G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 117, pl. xxviii. figs. 6 a-f.

Funafala, and the lagoon dredgings, Rocky Islet (Sollas coll.). Also obtained from the lagoon dredgings, sample 17,  $8\frac{1}{2}$  miles from the Mission Church, 12 fathoms; and from dredgings off Tutanga, 50-60 fathoms (David coll.).

*XESTOLEBERIS GRACILIS*, G. S. Brady.

*Xestoleberis gracilis*, G. S. Brady, 1890, Trans. R. Soc. Edinb. vol. xxxv. p. 508, pl. iii. figs. 9, 10.

Brady's figured specimens came from Samoa. At Funafuti this species occurred in the lagoon dredgings, sample 18, 9 miles from the Mission Church,  $7\frac{1}{2}$  fathoms, and from dredgings off Tutanga, at 200 fathoms (David, Halligan and Finckh coll.).

*XESTOLEBERIS ACUMINALIS*, sp. nov. (Plate 37. figs. 4 a-c.)

Carapace compressed; in side view narrow and oblong, sides nearly straight; anteriorly produced into a pointed beak-like process; posterior extremity well-rounded; seen from below subquadrate, with sides compressed, especially in the middle; end view compressed ovate, with the ventral margin nearly flat, the dorsal arched. Length .26 mm.

From the lagoon dredgings, sample 17,  $8\frac{1}{2}$  miles from the Mission Church, 12 fathoms (David coll.).

*XESTOLEBERIS MARGARITEA*, G. S. Brady.

? *Cytheridea margaritea*, G. S. Brady, 1866, Trans. Zool. Soc. Lond. vol. v. p. 359.

*Xestoleberis margaritea*, G. W. Müller, 1894, Fauna und Flora des Golfes von Neapel, Mon. xxi. (Ostracoden), p. 336, pl. 25. figs. 43, 44; pl. 26. figs. 2, 7.

This species appears to be new to this area, and it is well distributed. It occurred in the beach-sand at Avalau Islet, and in the lagoon dredgings of Rocky Islet (Sollas coll.). Also in the soundings across the lagoon, sample 1,  $\frac{1}{2}$  mile from the Mission Church, 10 fathoms; sample 17,  $8\frac{1}{2}$  miles from the Mission Ch., 12 fathoms; sample 18, 9 miles from the Mission Ch.,  $7\frac{1}{2}$  fathoms; and from dredgings north of Pava, 36 fathoms (David coll.).

*XESTOLEBERIS VARIEGATA*, G. S. Brady.

*Xestoleberis variegata*; G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 129, pl. xxxi. figs. 8 a-g.

The previously known localities in the Pacific for this species  
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are the Fiji and Samoa Islands. It is frequent at Funafuti. Found in the lagoon dredgings, sample 1,  $\frac{1}{2}$  mile from the Mission Church, 10 fathoms; sample 18, 9 miles from Mission Ch.,  $7\frac{1}{2}$  fathoms; also in dredgings off Funamamu, 50 fathoms (David coll.).

*XESTOLEBERIS ? FOVEOLATA, G. S. Brady.*

*Xestoleberis ? foveolata*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 180, pl. xxx. figs. 1 *a-g*.

The above species has hitherto been known only from shallow water. The Funafuti specimen is not typical, in having a faintly pitted surface: it seems, however, to agree in outline with Brady's figured specimens. From the 'Penguin' soundings, Sample 3, 2715 fathoms.

*XESTOLEBERIS TUMEFACATA, G. S. Brady.*

*Xestoleberis tumefacta*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 128, pl. xxxi. figs. 4 *a-d*.

This has been previously recorded from the Admiralty Islands and from Nouméa, New Caledonia. One sample only was found at Funafuti, namely, in lagoon dredgings no. 8, 4 miles from the Mission Church, 26 fathoms (David coll.).

*XESTOLEBERIS CURTA, G. S. Brady.*

*Xestoleberis curta*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 126, pl. xxxi. figs. 6 *a-d*.

*X. curta* is a well-distributed form, and occurs, among other localities, at Nouméa, the Fijis, and Samoa. At Funafuti it is somewhat rare. From the lagoon dredgings, sample 14, 7 miles from the Mission Church, 26 fathoms; also in dredgings off Tutanga, at 200 fathoms (David, Halligan and Finckh coll.).

*XESTOLEBERIS NANA, G. S. Brady.*

*Xestoleberis nana*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 127, pl. xxxi. figs. 5 *a-c*.

Dr. Brady's specimen was obtained from Tongatabu at 18 fathoms. A single valve was found in the Funafuti material, from Tutanga at 200 fathoms (Halligan and Finckh coll.).

*CYTHERURA, G. O. Sars.*

*CYTHERURA MARCIDA, G. S. Brady.*

*Cytherura marcida*, G. S. Brady, 1890, Trans. R. Soc. Edinb. vol. xxxv. p. 508, pl. iii. figs. 24, 25.

This species was originally described from the Fijis and Samoa. It is very rare at Funafuti, and was found only in the beach-sand of Avalau Islet (Sollas coll.).

CYTHEROPTERON, *G. O. Sars.*

CYTHEROPTERON SCAPHOIDES, *G. S. Brady.*

*Cytheropteron scaphoides*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 136, pl. xxxiii. figs. 1 *a-d*.

A single carapace was found in the dredgings off Tutanga, 50-60 fathoms (David coll.).

CYTHEROPTERON INTERMEDIUM, *G. S. Brady.*

*Cytheropteron intermedium*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 137, pl. xxxiv. figs. 1 *a-d*.

A single valve was obtained in the sand from the 2nd boring (Sollas) at 40 feet down.

CYTHEROPTERON ELATUM, *G. O. Sars.*

*Cytheropteron elatum*, G. O. Sars, 1865, Oversigt af Norges marine Ostracoder, p. 81; Brady & Norman, 1899, Sci. Trans. R. Dublin Soc. vol. iv. p. 214, pl. xx. figs. 8-10.

This species is not uncommon at Funafuti. It appears to have been hitherto recorded only from localities in high latitudes. The Pacific specimens differ in no essential points from the northern form, as regards the carapace.

From the sand of the 1st boring near the surface; from the lagoon dredgings, Rocky Islet (Sollas coll.). Also from dredgings off Funamanu, 50 fathoms; and off Tutanga, 200 fathoms (David coll.).

CYTHEROPTERON ASSIMILE, *G. S. Brady.*

*Cytheropteron assimile*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 138, pl. xxxiv. figs. 3 *a-d*.

A characteristic valve of this species was found in the sand of the 2nd boring (Sollas) at 40 feet from the surface. It also occurred in the beach-sands at Avalau Islet (Sollas coll.).

CYTHEROPTERON LONGICAUDATUM, *G. S. Brady.*

*Cytheropteron longicaudatum*, G. S. Brady, 1890, Trans. R. Soc. Edinb. vol. xxxv. p. 511, pl. iii. figs. 18, 19.

The original specimens came from Fiji; our examples, single valves only, came from the beach-sand, Avalau Islet (Sollas coll.),

and from the dredgings off Tutanga, at 50-60 and 200 fathoms (David coll.).

BYTHOCYTHERE, *G. O. Sars.*

BYTHOCYTHERE ARENACEA, *G. S. Brady.*

*Bythocythere arenacea*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 142, pl. xxxiii. figs. 3 *a-g*. [*B. arenosa* on plate.]

This species was described by Dr. Brady from specimens obtained at Torres Strait.

It is represented by one imperfect valve, from Funafuti, from the sand of the 1st boring (Sollas), near the surface.

BYTHOCYTHERE ARMATA, sp. nov. (Pl. 37. figs. 6 *a, b*.)

Carapace elongated, seen from the side oblong; height equal to more than half the length; anterior extremity rounded at the ventral angle, sloping backwards toward the dorsal angle; posterior extremity tapering, and terminating in a blunt process towards the dorsal angle. Dorsal edge slightly convex and sinuous; ventral straight. The antero-ventral border is armed with three blunt spines. Surface of carapace produced near the middle of the lower third into strong salient alæ. A surface ornamentation of polygonal pittings nearly covers the valve, excepting where the surface is relieved along the ventral border by two parallel ridges. Length of carapace 77 mm.

This form to a certain degree exhibits characters pertaining to two known species of *Bythocythere*; in lateral outline it clearly approaches *B. pumilio*\*, and in the size and position of the lateral alæ it somewhat resembles *B. velifera*†.

This species occurred at Tutanga at 200 fathoms (David coll.).

SECTION II. MYODOCOPA.

Family CYPRIDINIDÆ.

SARSIELLA, *Norman.*

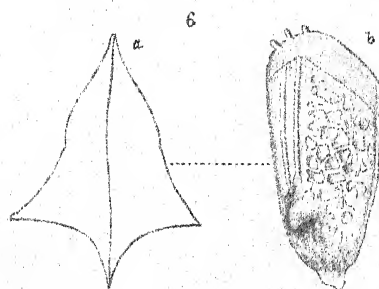
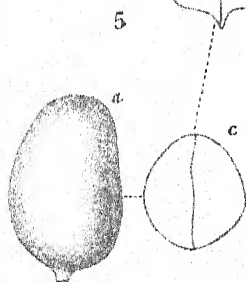
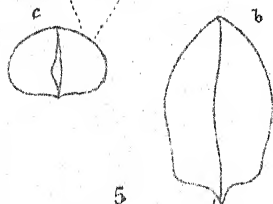
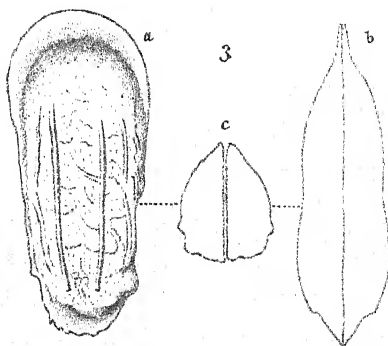
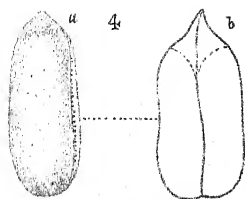
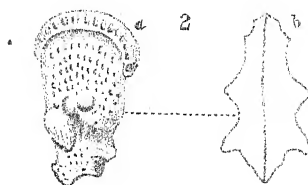
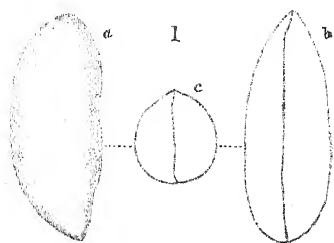
SARSIELLA SCULPTA, *G. S. Brady.*

*Sarsiella sculpta*, G. S. Brady, 1890, Trans. R. Soc. Edinb. vol. xxxv. p. 516, pl. i. figs. 17-20.

This species has been recorded previously from New Caledonia

\* G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 142, pl. xxxiii. figs. 4 *a-d*.

† Id. ibid. p. 143, pl. xxxiii. figs. 5 *a-c*.



F. Chapman ad. nat. del.  
M.P. Parker lith.

Parker & West imp.

NEW OSTRACODA FROM FUNAFUTI.





and Fiji. A partially dried shell, without doubt belonging to the above species, was found in the dredgings north of Pava, Funafuti, 35 fathoms (David coll.).

### SECTION III. PLATYCOPA.

#### Family CYTHERELLIDÆ.

##### CYTHERELLA, Jones.

##### CYTHERELLA VENUSTA, G. S. Brady.

*Cytherella venusta*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 176, pl. xliii. figs. 4 a-d.

This elegant little form is quite common at Avalau Islet, Funafuti; and was found also in the sand from the 1st boring, near the surface (Sollas). The specimens on which Dr. Brady's description was based came from the reefs at Honolulu.

##### CYTHERELLA CINGULATA, G. S. Brady.

*Cytherella cingulata*, G. S. Brady, Les Fonds de la Mer, tom. i. p. 159, pl. xvii. figs. 24, 25; id., Rep. Chall. Exped., Zool. pt. iii. p. 177, pl. xliii. figs. 1 a-g and figs. 2 a-d.

This species has been previously found in shallow water at Hong Kong, Port Jackson, and off Booby Island.

*C. cingulata* is very rare at Avalau Islet, Funafuti (Sollas coll.).

#### EXPLANATION OF PLATE 37.

- Fig. 1. *Argillacea affinis*, sp. nov.: a, right valve; b, dorsal aspect; c, posterior view.  $\times 45$ .
2. *Cythere pectunculata*, sp. nov.: a, left valve; b, ventral edge view.  $\times 45$ .
3. *Cythere phyllioides*, sp. nov.: a, left valve; b, dorsal aspect; c, posterior view.  $\times 45$ .
4. *Arctoleberis acuminalis*, sp. nov.: a, right valve; b, ventral aspect; c, posterior aspect.  $\times 90$ .
5. *Loxoconcha tumida*, sp. nov.: a, right valve; b, ventral aspect; c, posterior view.  $\times 45$ .
6. *Bythocythere armata*, sp. nov.: a, left valve; b, dorsal aspect.  $\times 45$ .

On the Structure and Affinities of the Tanganyika Gastropods  
*Chytrea* and *Limnotrochus*. By LETTICE DIGBY. (From  
the Biological Laboratory, Royal College of Science.)  
(Communicated by Prof. G. B. HOWES, F.R.S., Sec. Linn.  
Soc.)

[Read 20th February, 1902.]

(PLATES 38-40.)

THIS paper is based on material which formed part of the collection brought by Mr. J. E. S. Moore from Lake Tanganyika. He has kindly placed at my disposal specimens of both *Chytrea Kirkii* and *Limnotrochus Thomsoni*, and has greatly helped me in my work.

#### CHYTREA.

The genus *Chytrea* was separated by Moore from Smith's original *Limnotrochus* (4. p. 307), the older generic name being reserved for the reception of the single species *Limnotrochus Thomsoni*. The genus is now represented by a single species, *Chytrea Kirkii* (= *L. Kirkii*, Sm.), and is one of the most characteristic forms among the group of peculiar operculate molluscs found only in Lake Tanganyika. It has been generally placed among the Hydrobiidae (*cf.* Fischer 2.), a family often used as a receptacle for curious and abnormal types which have not been satisfactorily classed. But in 1897, Moore (4. p. 307) regarded it as more probably belonging to the Xenophoridae, on account of its conchological similarity to numerous fossils which are referred to that group. Up to the present time, however, the anatomy of the animal has never been described.

*External Features.*—The shell (Pl. 38. figs. 1 & 2) has already been described by Smith (8. p. 286). The horny operculum (fig. 3) is of the Littorinoid type, the inner surface being convex and the outer concave. The tentacles are long and filiform, and the eyes are situated on tubercles at their bases.

*Nervous System.*—The nervous system seems to be transitional between the dialyneurous and the zygoneurous types (Pl. 39. fig. 14). The cerebral ganglia (*g.c.*) are closely approximated, and the pleural ganglia (*g.p.*) are separated from them by a

slight constriction. The supra-intestinal cord (*n.sp.*) is considerably elongated; from the supra-intestinal ganglion (*g.sp.*) arise two nerves, the left pallial nerve (*n.p.'*) and the visceral (*n.v.'*). A very fine nerve (*c.p.'*) connects the left pleural ganglion with the pallial nerve, which it joins soon after its origin from the supra-intestinal ganglion. The sub-intestinal cord (*n.si.*) is somewhat shortened. In like manner the sub-intestinal ganglion (*g.si.*) gives rise to the right pallial (*n.p."*) and the right visceral nerve (*n.v."*). A nerve connects the right pleural ganglion and the right pallial nerve (*c.p."*). The visceral nerves (*n.v.'*, *n.v."*) unite by a straight commissure at the base of the mantle-cavity. The pleuro-pedal and cerebro-pedal connectives are long (fig. 15). The pedal ganglia (*g.pe.*) each give off three nerves, two of which run anteriorly and one posteriorly. The otocysts lie close behind the pedal ganglia; they are filled with many barrel-shaped otoliths (fig. 16) of various sizes.

*Radula*.—The radula (Pl. 39. fig. 20) has a feature which is also a characteristic distinctive of the radula of *Hipponyx conicus* (cf. 9. vol. i. p. 162), there being a strong pointed projection on the admedian tooth which overhangs the inner end of its serrated edge. The lateral teeth are sharply pointed and serrated. Possibly this acute form of dentition indicates a carnivorous habit.

*Viscera*.—The mouth is carried on a short snout, and opens into the buccal mass (Pl. 39. fig. 13) (*b.m.*), which leads into a long and very slightly coiled œsophagus (*œ.*). The stomach (*st.*) is two-chambered (Pl. 39. fig. 13 & Pl. 40. fig. 25). The anterior stomachic chamber contains a crystalline style (*s.c.*); the posterior bears a small, but complete spiral cæcum (*cæ.*). The intestine (*i.*) arises from the lower portion of the anterior chamber of the stomach, and coiling twice, bends sharply forward. The rectum (*r.*) attains a considerable dimension, since its walls are very glandular, but it narrows suddenly before opening by the anus (*a.*), which has a circular, thickened rim.

The "liver" (*l.*) occupies a great portion of the visceral mass, and a bile-duct opens at *b.*

The kidney (*k.*) is large, and the renal aperture (*a.r.*) is far back in the mantle-cavity (Pl. 39. figs. 12 & 13).

The heart (*v.* & *aur.*) (Pl. 39. fig. 13) is of the ordinary Monotocardian type. The gill (Pl. 39. fig. 13, *g.*) extends throughout the mantle-cavity, and consists (Pl. 38. fig. 10)

of a single row of plumes (*g.*'), with blunt rounded ends (Pl. 39. fig. 17), each of which is attached along its dorsal edge, and contains a skeletal support continued from the point of attachment. Hypobranchial glands are present (*g.h.*, Pl. 39. fig. 12).

The reproductive aperture (*a.g.*) (Pl. 39. fig. 12) is a wide oval slit. This, in the female (Pl. 38. fig. 11), leads into a large dilated uterus (*u.*), which is continued to the posterior end of the mantle-cavity, where it is seen to arise from an oviduct (*ov.*), which ramifies in the genital tissue (*g.g.*). This tissue (Pl. 39. fig. 13) is intimately bound up with the "liver" (*l.*), and with it composes the greater part of the visceral hump.

There is an accessory gland-like organ (*g.g.'*, Pl. 38. fig. 11) closely adhering to the uterus (*u.*), which protrudes into the mantle-cavity. Its function is unknown, but it may possibly secrete an investment for the eggs. The reproductive organs of the male have not been identified, and it is not known whether the accessory gland-like organ is present in the male, or whether *Chytra Kirkii* is viviparous or not.

*Affinities.*—In attempting to define the affinities of *Chytra*, by far the most important feature presented by this genus is the obvious combination of characters distinctive of several well-known Prosobranchiate forms. Thus the nervous system is strikingly like that of *Capulus* (1. pl. 8. fig. 35). So also, when viewed from the side, the position and relationships of the pedal, pleural, and cerebral ganglia, with their connectives, are very similar to those figured by Bouvier for *Xenophorus*. *Chytra* may be further compared to the Xenophoridae in the obviously similar character of its shell (4. pp. 307 & 317, pl. 23. fig. 6A), and consequently the shape of the body; in the situation of the eyes on the tentacles; in the general character of the gill and gill-plumes; in the filiform osphradium; in the position of the renal aperture; and in the presence of an accessory gland-like organ in relation to the genital apparatus.

This apparent affinity of *Chytra* to the Xenophoridae is perhaps strengthened by a detailed comparison of *Chytra Kirkii* with *Aporrhais pes-pelecani* (cf. Pl. 39. fig. 13 & Pl. 40. fig. 22). In both, there is the same arrangement of the buccal mass, a more or less comparable radula (Pl. 39. fig. 20), a very similar gill, and hypobranchial glands (*g.h.*, Pl. 40. fig. 22). Further, the characters of the nervous system of *Aporrhais pes-pelecani*

(Pl. 40. fig. 23) are generally similar to those of *Chytra Kirkii*\*, except that in *Aporrhais* the supra- and sub-intestinal cords are considerably elongated, and there is a direct zygoneurous connection on the right side. In *Chytra Kirkii* there is, however, also a practically zygoneurous condition, the connecting nerve, instead of joining the sub-intestinal ganglion (Pl. 39. fig. 14), joins the pallial nerve immediately after its origin. Lastly, the whole stomachic apparatus is similar: there is a well-developed crystalline style in *Aporrhais* (st., Pl. 40. fig. 22), and the internal valvular portion of the spiral cæcum is present, but not the complete structure. Further, the barrel-shaped otoliths which are found in *Chytra* are also found in *Typhobia* (6. p. 188) and in the Cerithiidae. The presence of the slightly developed spiral cæcum in *Chytra* brings this interesting form into relationship with *Trochus* (7. & Pl. 40. fig. 27), *Pleurotomaria* (fig. 28), and *Nassopsis* (5. p. 189, & Pl. 40. fig. 26). The presence of a crystalline style characteristic of *Chytra* is characteristic of widely different molluscan forms. It is present in all the halolimnic Gastropods of Tanganyika, in some Trochidae, *Pteroceras*, and the Strombidae. These facts suggest that in *Chytra* we are probably dealing with the direct ancestor of the families Hipponycidae and Capulidae, since the genus combines the nervous system of the one and the radula of the other; *i. e.*, two of the most salient features of Prosobranchiate anatomy.

LIMNOTROCHUS THOMSONI. (Pl. 38. figs. 1-9; Pl. 40. fig. 24.)

*Limnotrochus Thomsoni* is now the single species of the genus (1). Like *Chytra*, it is an inhabitant of Lake Tanganyika, living at considerable depths and apparently in solitude, for never more than a single specimen is dredged at a time. Consequently it is difficult to procure the living animal, but the empty shells are pretty common. The conchological characters (Pl. 38. figs. 1, 2) presented by the genus, however, need no comment here, as they have already been fully described and figured (8. p. 285). The operculum (Pl. 38. fig. 3) is "horny" and somewhat oblong in shape, concave towards the inner side, and Littorinoid in character.

\* Haller's figure (3. taf. xviii. fig. 6) of the nervous system of *Chenopus (Aporrhais) pes-pelecani* and his description of the same (p. 579) is absolutely incorrect. He must either have figured an entirely different animal, or the specimen that he dissected was quite abnormal.

*External Features.*—The general features of the mantle-cavity (Pl. 38. fig. 9), the character of the tentacles, the position of the eyes and of the apertures, are all very like those already described in *Chytra*, the most apparent differences being the smaller size of *Limnotrochus Thomsoni*, the flatter shape of the visceral hump, and the pigmented band down the centre of the snout and on the inner sides of the tentacles.

*Nervous System.*—The nervous system is zygoneurous on the right (Pl. 38. figs. 5, 6). The ganglia and nerves are protected by a closely adhering connective tissue which contains skeletal elements. The cerebral ganglia (*g.c.*) are separated by a distinct cerebral commissure, and are situated decidedly further back than in *Chytra*. The right pleural ganglion (*g.p.*′) gives off a fairly long supra-intestinal cord, which connects the right pleural ganglion with the supra-intestinal ganglion. A fine nerve comes off from this cord just before it unites with the supra-intestinal ganglion. This nerve appears to join with another arising from the left pleural ganglion, but I was not able, actually, to see the connection. The supra-intestinal ganglion (*g.sp.*) gives off the left visceral nerve. The sub-intestinal cord springs from the left pleural ganglion, and soon passes into the sub-intestinal ganglion (*g.si.*) which, in the usual way, gives off the right pallial and right visceral nerves. A very short nerve (*z*) connects the sub-intestinal ganglion directly with the right pleural. Viewed from the side (fig. 6), the relative position of the cerebral and pleural ganglia is rather curious, the pleural ganglia being posterior and ventral to the cerebrals and nearly fused with the pedal ganglia, from which they are separated by a very short pleuro-pedal commissure (*c.p.pe.*′), the cerebro-pedal commissure (*c.c.pe.*′) being longer. Each pedal ganglion gives off two nerves to the foot, but I was not able to see the nerve leading to the otocysts. The otocysts contain many rectangular otoliths (Pl. 38. fig. 7).

*Radula.*—The radula (Pl. 38. fig. 4) is distinctive, its most striking feature being the blunt protuberance on the underside of each of the two lateral teeth. The admedian tooth is large, and has a broad upper portion, bluntly serrated along its anterior face, which overhangs a lower portion, whose sharply serrated edge is turned towards the median tooth.

*Viscera.*—The mouth leads into a short buccal mass. A pair of salivary glands, diminutive sacculated organs, open into the

buccal cavity. The oesophagus is straight, except for a sharp bend before it opens into the stomach (Pl. 40. fig. 24), which, like that of *Chytra*, has two chambers, the anterior of which contains a large crystalline style. The walls of the posterior chamber are very thin; those of the anterior chamber very thick and muscular. The most remarkable feature about the gastric apparatus of *Limnotrochus* lies, however, in the fact that it possesses an even better developed spiral cæcum (cæ., Pl. 40. fig. 24) than *Chytra* (fig. 25) itself. The base of the cæcum is connected with a longitudinal fold which extends to the anterior chamber; the aperture of a bile-duct (b.) lies below the spiral cæcum. The coils of the intestine, the rectum, and the anus are very similar to those of *Chytra*. The kidney is fairly large, and occupies the same position as in *Chytra*, surrounding the "monotocardian" heart.

The gill (g., Pl. 38. fig. 9) is short, the gill-plumes are triangular, and the osphradium (o.) is filiform.

In both specimens which I dissected, the long slit-like aperture of the genital gland (Pl. 38. fig. 9, a.g.) opened into a considerably dilated sac, slightly curved towards the left side of the animal. In the case of one specimen this was undoubtedly the uterus, as it contained bundles of very long spermatozoa; and in the genital tissue of the visceral coil there were well-developed ova. There is a large accessory gland-like organ (fig. 9, g.g.) like that of *Chytra*, which spreads posteriorly into a tongue-shaped body, partly underlying the uterus (cf. fig. 8).

*Affinities.*—It will have been gathered from the preceding description that *Limnotrochus Thomsoni*, in the general plan of its organization, and in the disposition of the viscera, is distinctly like the genus *Chytra*, but in minor details very different. The shell of *Limnotrochus Thomsoni* (Pl. 38. figs. 1, 2) may be compared to some of the so-called Littorinas of the marine Jurassic deposits, and in particular to *Littorina sulcata* (4. p. 317). It is also dissimilar to that of *Cancellaria*.

Curiously enough, the nervous system of *Limnotrochus* (Pl. 38. fig. 5) is also like that of *Voluta* (3) and *Cancellaria*, there being the same condensation of the cerebral, pleural, and pedal ganglia, and the same zygoneurous condition of the right side. The radula (Pl. 38. fig. 4) cannot be associated with any known type, its nearest approach is to be found in the varieties of the Melanoid group (9. vol. i. p. 121).



Lastly, the pigmented snout, the triangular gill-plumes, so characteristic of the *Rhachiglossa*, the longitudinal fold and the other features of the stomach, and the simple pouch-like salivary glands, all bring *Limnotrochus* into close relationship with *Typhobia*.

Like *Chytrea*, *Limnotrochus* has thus obviously scattered affinities, and it is more difficult to place than even *Chytrea* itself. It is undoubtedly allied both to *Chytrea* and to *Typhobia*, as well as to the Stromboid group represented by the genera *Strombus* and *Aporrhais*; and it is perhaps more nearly allied to these genera than to any other living types. But, on the other hand, it is quite distinct from them all, and must, at any rate for the present, be regarded as unique.

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## EXPLANATION OF THE PLATES.

*Reference Letters.*

<i>a.</i> , anus.	<i>g.s.</i> , salivary glands.
<i>b.</i> , aperture of the bile-duct.	<i>g.sl.</i> , sub-intestinal ganglion.
<i>a.æ.</i> , opening of the œsophagus into the stomach.	<i>g.sp.</i> , supra-intestinal ganglion.
<i>a.g.</i> , genital aperture.	<i>g.g.</i> , genital groove.
<i>a.i.</i> , opening of intestine leading from the stomach.	<i>i.</i> , intestine.
<i>a.r.</i> , renal aperture.	<i>k.</i> , kidney.
<i>au.</i> , auricle.	<i>l.</i> , liver.
<i>b.m.</i> , buccal mass.	<i>ma.</i> , mantle.
<i>æ.</i> , spiral cæcum.	<i>m.e.</i> , cut edge of mantle.
<i>c.c.pe.</i> ', left cerebro-pedal connective.	<i>n.p.'</i> , left pallial nerve.
<i>c.p.</i> , pericardial cavity.	<i>n.p."</i> , right pallial nerve.
<i>c.p.'</i> , left pleural connective.	<i>n.sl.</i> , sub-intestinal nerve.
<i>c.p."</i> , right pleural connective.	<i>n.sp.</i> , supra-intestinal nerve.
<i>c.p.pe.</i> ', pleuro-pedal connective.	<i>n.v.'</i> , left visceral nerve.
<i>e.</i> , eye.	<i>n.v."</i> , right visceral nerve.
<i>g.</i> , gill.	<i>o.</i> , osphradium.
<i>g.'</i> , gill-plume.	<i>æ.</i> , œsophagus.
<i>g.c.'</i> , left cerebral ganglion.	<i>ot.</i> , otocyst.
<i>g.c."</i> , right cerebral ganglion.	<i>ov.</i> , oviduct.
<i>g.e.</i> , cut edge of gill.	<i>r.</i> , rectum.
<i>g.g.</i> , genital gland.	<i>s.</i> , snout.
<i>g.g.'</i> , accessory genital gland.	<i>s.c.</i> , crystalline style.
<i>g.h.</i> , hypobranchial gland.	<i>s.s.</i> , style-sac.
<i>g.p.'</i> , left pleural ganglion.	<i>st.</i> , stomach.
<i>g.p."</i> , right pleural ganglion.	<i>t.</i> , tentacle.
<i>g.pe.</i> , pedal ganglion.	<i>u.</i> , uterus.
	<i>v.</i> , ventricle.
	<i>z.</i> , zygonerous connection.

## PLATE 38.

- Fig. 1. *Limnotrochus Thomsoni*. Front view of shell.
2. " " Back view of shell. Both natural size.
3. " " Operculum, external face.  $\times 6$ .
4. " " Radula, 2 laterals, admedian and median teeth; from a drawing by Mr. J. E. S. Moore. Magnified.
5. " " Nervous system, dorsal aspect.
6. " " " lateral aspect. Both  $\times 10$ .
7. " " Otolith. Highly magnified.
8. " " Female reproductive organs.  $\times 7$ .
9. " " Mantle-cavity, with mantle reflected to the right.  $\times 7$ .
10. *Chytrea Kirkii*. The gill, with mantle reflected to the left.  $\times 12$ .
11. " " Female reproductive organs.  $\times 6$ .

## PLATE 39.

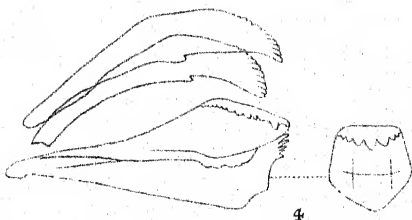
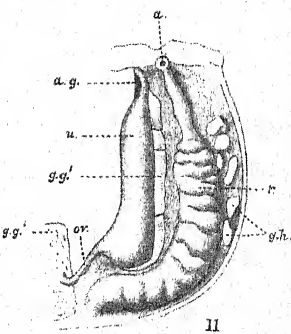
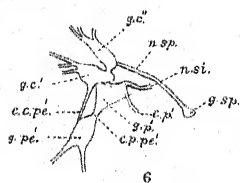
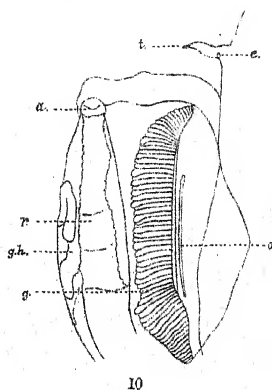
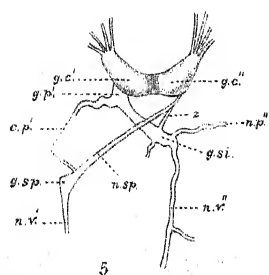
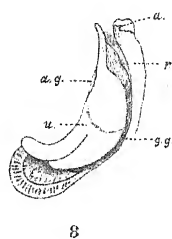
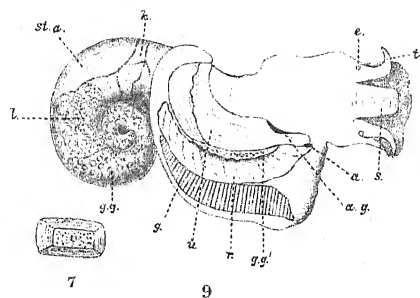
- Fig. 12. *Chytrea Kirkii*. Mantle-cavity, with mantle reflected to the right side.  $\times 10$ .
- |     |   |   |   |
|-----|---|---|---|
| 13. | " | " | Dissection of the alimentary canal. $\times 10$ .   |
| 14. | " | " | Nervous system, dorsal aspect. $\times 10$ .  |
| 15. | " | " | " lateral aspect. $\times 10$ .   |
| 16. | " | " | Otolith. Highly magnified.  |
| 17. | " | " | Gill-leaves, isolated. Highly magnified.  |
| 18. | " | " | The shell, lateral aspect.  |
| 19. | " | " | " from beneath. Both slightly enlarged.   |
| 20. | " | " | Radula, 2 laterals, admedian and median teeth; from a drawing by Mr. J. E. S. Moore. Magnified. |
| 21. | " | " | Operculum, external face. $\times 6$ .  |

## PLATE 40.

- \* Fig. 22. *Aporrhais pes-pellicani*. General dissection.  $\times 2$ .
- |       |                                 |   |   |
|-------|---------------------------------|---|---|
| * 23. | "                               | " | Nervous system from the dorsal aspect.<br>$\times$ about $2\frac{1}{2}$ . |
| * 24. | <i>Limnotrochus Thomsoni</i> .  |   | Dissection of the stomach. $\times 10$ .                                  |
| * 25. | <i>Chytrea Kirkii</i> .         |   | The same. $\times$ about 10.  |
| * 26. | <i>Nassopsis nassa</i> .        |   | Dissection of the stomach. $\times 10$ .                                  |
|       | <i>Trochus turbinatus</i> .     |   | The same, after Robert (7). $\times 10$ .                                 |
|       | <i>Pleurotomaria Berychii</i> . |   | The same. From a drawing by the late Mr. F. Woodward. $\times 10$ .       |

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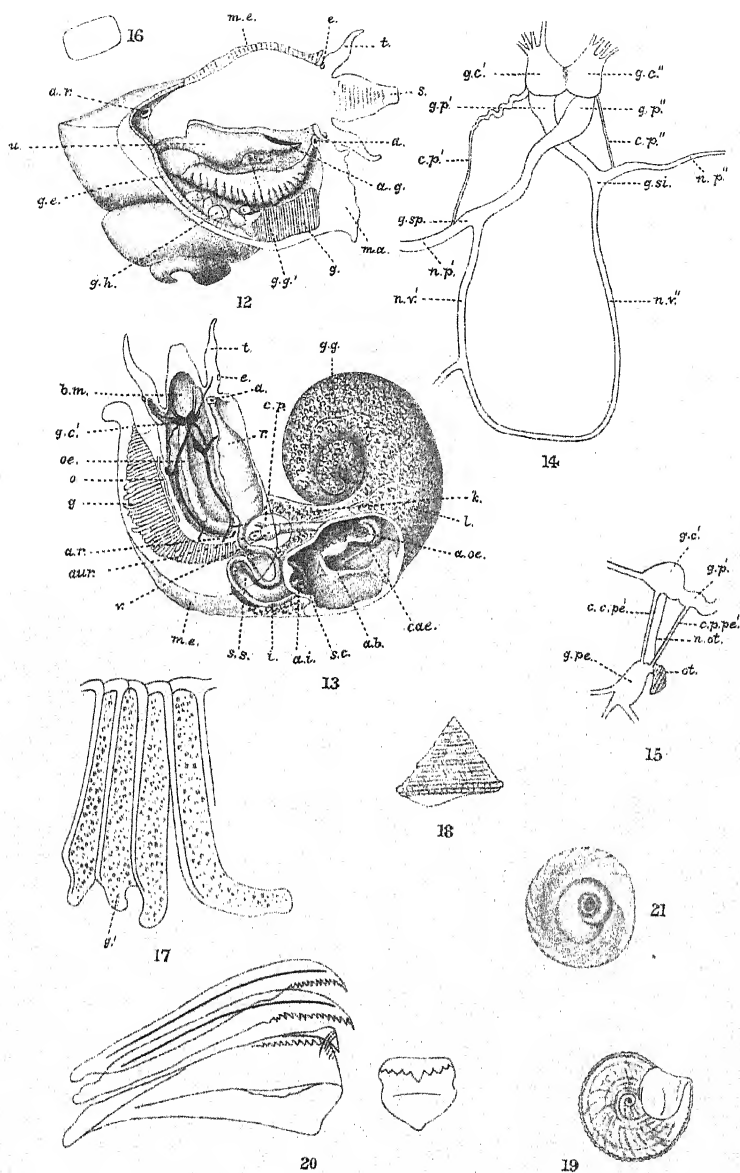
\* The figures marked thus are from drawings by Mr. J. E. S. Moore.



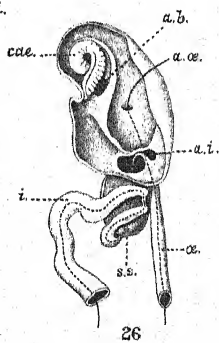
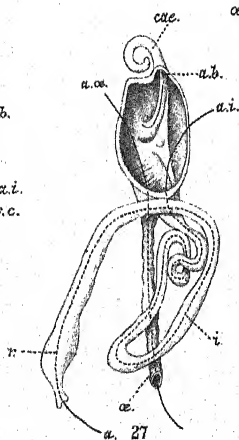
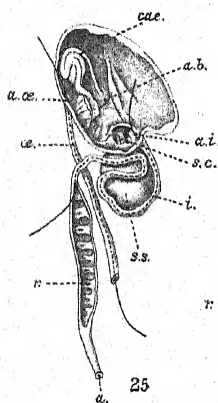
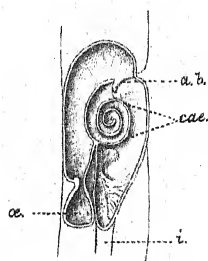
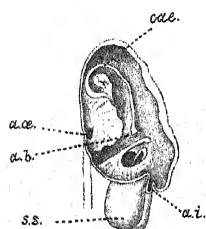
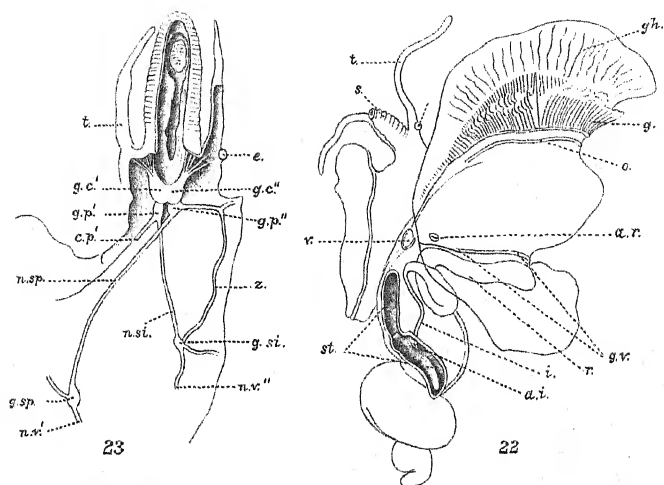
L.D. del.  
M.P. Parker lith.

Parker & West imp.









L.D. del.  
M.P. Parker lith.

Parker & West imp.

# LIMNOTROCHUS & CHYTRA.

WITH APORRHAI, NASSOPSIS, PLEUROTOMARIA, & TROCHUS.





Notes on the Brain of *Macroscelides* and other Insectivora.

By G. ELLIOT SMITH, M.D., Fellow of St. John's College, Cambridge; Professor of Anatomy, Egyptian Government School of Medicine, Cairo. (Communicated by Prof. G. B. HOWES, F.R.S., Sec. L.S.)

[Read 1st May, 1902.]

My friend Dr. Robert Broom has recently discovered that the organ of Jacobson and its cartilages in the Elephant-Shrew present a peculiarly close similarity to the corresponding parts in the Marsupialia, and has moreover found\* metatheroid features in the skeleton of *Macroscelides* in addition to those previously recorded by Kitchen Parker. It seemed to him that it would be of considerable interest to submit to careful examination the other parts of the body which present distinctive features in the Marsupialia. Accordingly he has kindly sent me the heads of an adult and a foetal *Macroscelides proboscideus*, and asked me to make a report upon them.

The heads had been simply placed in spirit, so that the brains were not in a condition altogether favourable for histological study. In fact the foetal brain was too soft to permit of anything more than a study of the configuration of its surface. The adult brain, however, was sufficiently firm to be cut in paraffin. The sections were stained with lithium-carmin.

As the presence or absence of metatheroid features can in almost all mammalian brains be detected by the naked eye, I first submitted the brain to a thorough examination both by this means and with the help of a lens. I then split it in the mesial sagittal section and studied the mesial surface in the same way; and as many points still needed elucidation, I cut a series of coronal sections of one hemisphere and dissected the other.

The brain of *Macroscelides* has been figured from the dorsal aspect by Peters†; and its general features need not be described in detail, since they differ to no great extent from those of *Talpa*, which have been so thoroughly described in Ganser's classic monograph‡.

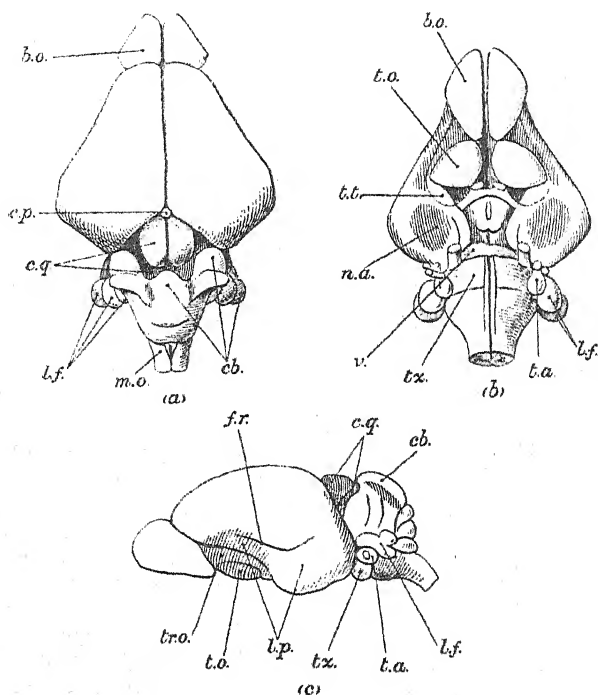
\* Proc. Zool. Soc. 1902, vol. i., March, 18th.

† Peters, 'Reise nach Mossambique,' Zool. i. Säugethiere, pl. xxiv. fig. 13. Berlin, 1852.

‡ Vergleich. Anat. Studien. "Ueber das Gehirn d. Maulwurfs," Morph. Jahrb. Bd. vii. p. 591 (1881).

The large projecting olfactory bulbs recall those of the Marsupial *Perameles*. The features of the base of the brain—the large tubercula olfactoria, the tracti olfactorii and their large tubercles, the peculiar flattening of the nuclei amygdale.

Fig. 1.



*Macroscelides proboscideus*; the brain,  $\times 2$ .

(a) Dorsal aspect. (b) Ventral aspect. (c) Left lateral aspect.

b.o., bulbus olfactorius. cb., cerebellum. c.q., corpora quadrigemina. f.r., fissura rhinalis. l.f., lobus flocculi. l.p., lobus pyramidalis. m.o., medulla oblongata. n.a., nucleus amygdale. t.a., tuberculum acusticum. t.o., tractus olfactorius. t.t., tuberculum tractus olfactorius. t.z., trapezium. v., pons Varolii.

the small pons Varolii, and the large trapezoid bodies—all closely resemble those which are found equally in the Insectivora, Polyprodont Marsupials, and the Dasypodidæ. The peculiar lateral extension of the pyriform lobes of the hemispheres into

a distinct angle occurs also in *Erinaceus*, *Talpa*, and *Perameles*. So far as the shape of the cerebral hemispheres, and especially also that of the floccular lobes of the cerebellum, is concerned, the brain more closely resembles that of *Perameles* than that of the Insectivora. At the same time, distinctions of this kind have little if any ordinal value.

The rhinal fissure is incomplete, being intermediate in this respect between *Erinaceus* and *Perameles*.

The caudal margin of each hemisphere (fig. 1 a) consists of two limbs of equal length meeting at an angle of slightly more than 90°. A large lozenge-shaped space is left between the mesial half of each hemisphere and the cerebellum, and "in this the pineal body, the whole of the anterior and a considerable part of the posterior pair of corpora quadrigemina are exposed. Such a complete uncovering of the mid-brain is rare in mammals. A much slighter degree of uncovering occurs in the Marsupial *Dasyurus* and some of the smaller *Dasyuridæ*. A similar condition occurs in the Insectivore *Centetes*, but, as Forsyth Major has pointed out, it is probably due to secondary retrogressive change.

It is strange to find a similar exposure of the mid-brain in the aberrant *Galeopithecus*\*—in a brain possessing deep and well-defined calcarine, intercalary, suprasylvian, orbital, and pseudo-sylvian sulci. It also occurs in most of the Microchiroptera.

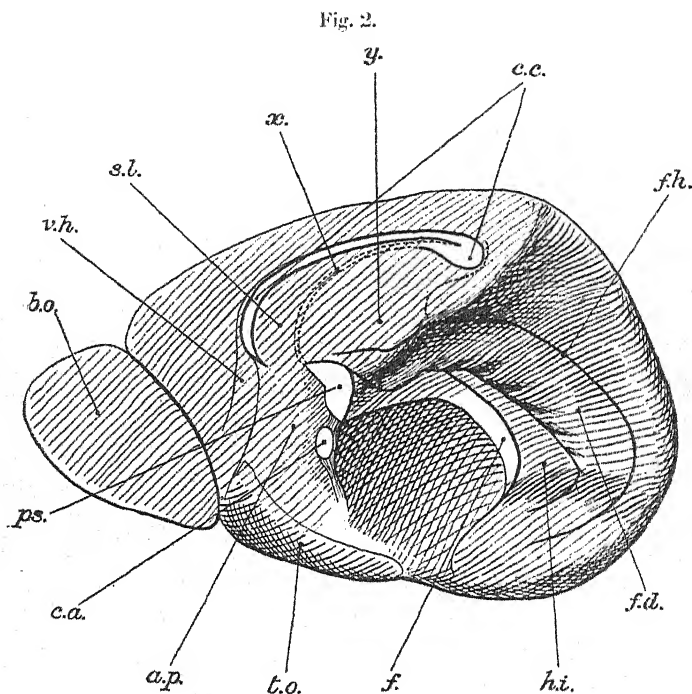
The cerebellum is very simple and closely resembles that of *Perameles*. This is of little systematic importance, because the mere wiping-out of some of the cerebellar fissures and the elongation of the floccular lobe in *Erinaceus* would produce the *Perameles*-type.

The only features of crucial importance in attempting to distinguish the brain of an Insectivore from that of a Polyprotodont Marsupial are those of the cerebral commissures and the hippocampus. The Marsupial has a small dorsal commissure which is derived wholly from the fornix, whereas the upper commissure of the Insectivore is derived partly from the fornix and partly

\* For some excellent specimens I am indebted to the kindness of Dr. Charles Hose of Borneo. The only accounts of this brain, viz., those of Gervais (Journal de Zoologie, tome i., 1872) and Leche (Kongl. Sv. Vet.-Akad. Handl. Bd. xxi. p. 48, Stockholm, 1886), are far from perfect. I have given fuller information concerning this brain in my forthcoming Catalogue of the Collection of Brains in the Royal College of Surgeons' Museum.

from the neopallium, the latter moiety constituting the corpus callosum.

On the mesial surface of the hemisphere of *Macroscelides* there is a most extraordinary condition (fig. 2).



*Macroscelides proboscideus*: right cerebral hemisphere,  
mesial aspect,  $\times 6$ .

*c.a.*, commissura anterior. *c.c.*, corpus callosum. *f.*, fimbria. *f.d.*, fascia dentata. *f.h.*, fissura hippocampi. *h.i.*, hippocampus inversus. *ps.*, psalterium. *s.l.*, septum lucidum. *v.h.*, vestigia hippocampi. *y.*, area of subsplenial hippocampal flexure. *x.*, line of probable connection between the psalterium and splenium. Other references as for figure 1.

In the lamina terminalis there is a relatively (*i. e.* in comparison with that of Marsupials) small anterior commissure (*c.a.*), and yet, above it, a typically metatheroid psalterium (fornix-commissure, *ps.*) of a crescentic shape such as occurs in *Perameles*, *Notoryctes*, *Didelphys*, and *Myrmecobius*. The hippocampal formation (fig. 2, fascia dentata) extends forward on to

the upper surface of this commissure, just as happens also in the Metatheria; and yet, high up near the dorsal margin of the hemisphere, there is an undoubted corpus callosum. The shape of this body is no less peculiar than its extraordinary position. It is exceedingly large and thin, and exhibits a state of affairs which is almost unknown beyond the limits of the Primates. It is, moreover, provided with a plump splenium and a long hook-like genu ending in a sharp rostrum.

Both in shape, size, and position this corpus callosum (*c.c.*) is as unlike the primitive generalized condition of the corpus callosum, such as is found in *Erinaceus*, as it is possible to imagine.

The most primitive form of corpus callosum is exhibited in the brain of many small Bats such as *Nyctophilus*\*; but whether as the persistence of the original condition or as a secondary reversion to it, does not especially concern us now. In *Erinaceus*† the evolution of the corpus callosum is carried only slightly further.

In many small Insectivores like *Hemicentetes*, *Oryzoryctes*‡, and others, a similar state of affairs is found. In *Gymnura*§ and *Talpa* the corpus callosum is larger, but the condition is essentially the same. In *Chrysochloris*¶ there is an extraordinary elongation of the corpus callosum, such as we do not find in other small Insectivores, nor in the Edentate *Chlamydomorphus*, which in this respect resembles *Erinaceus* much more closely than does the Golden Mole.

But even in *Chrysochloris* the corpus callosum is not nearly so long as it is in *Macroscelides*, while in the former it has the primitive straight form. Thus while *Macroscelides* has the most specialized form of corpus callosum of all Insectivores, its psalterium retains the peculiar crescentic form found elsewhere only in the Marsupialia.

In all other mammals with a corpus callosum the growth of the latter modifies the shape of the psalterium by pulling it

\* Cf. "The Origin of the Corpus Callosum," Trans. Linn. Soc., ser. II. Zool. vol. vii. pt. 3 (1897).

† Cf. "The Relation of the Fornix to the Margin of the Cerebral Cortex," Journ. Anat. & Phys. vol. xxxii. 1898, p. 45.

‡ For the brain of *Gymnura* I am indebted to Dr. Charles Hose; for that of *Hemicentetes* and *Oryzoryctes* to Dr. Forsyth Major; and for that of *Chrysochloris* to Dr. Broom.

backward and stretching it. This has not happened in *Macroscelides*, and unfortunately I am unable to state what connection really exists between the corpus callosum and psalterium. In an examination of the mesial surface of the hemisphere with a lens, I was unable to find any connecting-link between the two commissures; nor did the histological investigation yield any more satisfactory result.

And yet from what we know of the evolution of the corpus callosum, we can safely predict that when better material is available (which Dr. Broom assures me will soon be the case) a bridge will be found in the position marked *x* in the diagram (fig. 2) joining the anterior limb of the psalterium to the under-leaf of the splenium. This bridge may not contain any nerve-fibres, and may thus realize a condition which we find in the *Hapalidæ*\*, but there must at least be a narrow lamina of neuroglia.

In the interval (*y*) between the corpus callosum and the psalterium there is a subsplenic hippocampal flexure of the usual structure, though of an unusually great size. I have traced the course of this flexure in a series of sections, and have been able to establish the fact that it does not differ essentially from that of *Erinaceus*.

As soon as I get better material I hope to publish full details of the minute structure of this interesting brain, and to compare it in detail with that of *Erinaceus*, *Gymnura*, *Talpa*, *Chrysochloris*, *Hemicentetes*, *Oryzoryctes*, and *Galcopithecus*.

I have written enough, however, to show that Parker's remark concerning the skeleton, that "we have a curious mixture of Marsupial (Metatherian) and Eutherian characters," might with equal truth be applied to the brain.

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\* Cf. "The Relation of the Fornix," Journ. Anat. & Phys. vol. xxxii. 1898, p. 52.

On the Early Condition of the Shoulder-Girdle in the Polyprotodont Marsupials *Dasyurus* and *Perameles*. By ROBERT BROOM, M.D., C.M., B.Sc. (Communicated by Prof. G. B. HOWES, F.R.S., Sec. L.S.)

[Read 1st May, 1902.]

(PLATE 41.)

IN 1897 I discovered that the Common Phalanger (*Trichosurus vulpecula*) has at birth a well-developed coracoid, which is firmly attached to the sternum, and I recorded the fact at the time in a short note in the 'Journal of Anatomy and Physiology' (1).

In 1899, Sir William Turner communicated to the Royal Society of Edinburgh for me a paper (2) dealing at length with the development of the shoulder-girdle in *Trichosurus vulpecula*, and containing some observations on the early condition of the girdle in *Pseudochirus* and *Petrogale*. Since then, through the kindness of my friends Prof. J. T. Wilson and Mr. J. P. Hill, of Sydney, I have been enabled to study one or two stages in the early development of the shoulder-girdle of two of the Polyprotodont genera—*Dasyurus* and *Perameles*.

*DASYURUS VIVERRINUS* (Early Stage). (Pl. 41. figs. 1 & 2.)

The younger of the two stages of Native Cat which I have examined measures in the curved condition 8 mm. greatest length, and had a head-length of 4 mm. At birth, according to Hill (3), the new-born young measures, when preserved in spirit, 5.5 mm. G.L. and 2.3 mm. H.L., so that the specimen examined would probably be 4 or 5 days old. In its general skeletal development it is slightly more advanced than is the new-born *Trichosurus*. In the head the following bones can be detected:—premaxillary, maxillary, lachrymal, jugal, squamosal, palatine, pterygoid, and mandible. In the post-cranial skeleton ossification has commenced in the scapula and in the first two ribs, while the clavicle is well ossified.

As in the Diprotodont marsupials which have been examined the early mammary foetal *Dasyurus* has a complete shoulder-girdle, the well-developed coracoids articulating with the sternum



The plane of the girdle lies as near as may be at right angles to the axis of the cervical vertebræ. The scapula (Pl. 41. fig. 1, *sc.*) in its lower two-thirds is a narrow, somewhat flattened rod, while above it expands into a relatively rather large antero-posteriorly directed plate. From the anterior border of the scapula, at a point near the union of the lower and the middle third, a well-developed acromion process (*ac.*) arises, and passes first forwards and slightly outwards and upwards, and then downwards and inwards to meet the clavicle (*cl.*). The lower end of the scapula forms with the coracoid (*co.*) the glenoid cavity. From along the upper border of the upper part of the acromion to the anterior border of the middle third of the scapula there stretches a thin bony plate, forming the scapular spine (*sp.*).

The coracoid (*co.*), which is about half the length of the scapula, and about as wide as the scapula is in its middle region, passes inwards, a little downwards, and very slightly forwards from its point of union with the lower end of the scapula, and forms an articulation with the side of the broad presternum (fig. 2, *p.st.*), just in front of the first rib. The inner end of the coracoid is slightly dilated, and while its posterior half forms the joint with the sternum, the anterior portion passes forwards towards the clavicle, and is continued into the undifferentiated tissue which surrounds that bone.

The clavicle (*cl.*) is a well-developed little osseous bar which passes directly outwards from near the anterior end of the sternum for some distance, and then turns abruptly upwards to meet the end of the acromion. The bone is surrounded by a thick layer of undifferentiated tissue, but no cartilage can be detected in connection with it.

The sternum (*st.*) is chiefly characterized by the great breadth of its anterior part—the presternum being about three times as wide as the posterior portion. From its widest point it gradually narrows to the point of union with the fourth rib; while in the posterior half the width is moderately uniform. There is a distinct xiphisternum (*x.st.*). The sternum gives attachment to eight pairs of ribs. Anteriorly the presternum ends rather abruptly, in marked contrast to the pointed condition of the anterior end in later stages.

The omosternum is not yet formed, and is represented by a mass of undifferentiated tissue between the inner end of the clavicle and the sternum.

DASYURUS VIVERRINUS (*Later Stage*). (Pl. 41. fig. 5.)

The larger of the two stages of the mammary foetal Dasyure which I have studied has a head-length of 8 mm. But though the foetus is so small, development has so far advanced that in the shoulder-girdle at least practically all the features displayed are those of the adult.

The scapula (*sc.*) has a broad blade as in the adult, with a well-developed spine running down near the middle of the outer side. The change in shape of the scapula from the narrow blade of the earlier stage is brought about by the remarkable manner in which ossification takes place. In the earlier stage, the only part of the scapula that is distinctly ossified is the spine, but ossification is just starting along the surface of the cartilage in the middle region. In this later stage, all the cartilage of the scapula, except along the upper border, the acromion process, and near the glenoid cavity, has been replaced by bony tissue. The bony development, however, has not been limited to the ossification of the cartilage, but has formed a moderately large bony plate, which passes forwards from what was the anterior border of the cartilaginous scapula, and has thus converted the narrow scapula of the early stage into the broad bony blade of the later. The coracoid (*co.*) has no longer any attachment to the sternum, and with the increased size of the girdle there has become considerable alteration in shape, so that the coracoid and the acromion are now mainly directly forwards.

The clavicle is long and slender; and there is now a distinct omosternal cartilage (*o.st.*), which lies between the point of the sternum and the clavicle.

The sternum (*st.*) differs in shape from that of the earlier stage. The presternum (*p.st.*), in front of the broad part which gives articulation to the first pair of ribs, tapers away to a rather slender point.

## PERAMELES OBESULA. (Pl. 41. fig. 6.)

The mammary foetus which I have examined measured 18.2 mm. greatest length and 9 mm. head-length. At this stage, which roughly corresponds to the later *Dasyurus* stage, the coracoid has lost all connection with the sternum.

The scapula is essentially similar to that of the adult. A well-developed spine runs down near the middle of the bone, and terminates in a rather broad, flat acromion, which latter, on

passing forward, terminates in a sharp point. The "prescapula" is well developed, and here, as in *Dasyurus*, a large part of it has no pre-existing cartilaginous basis. In the figure a dotted line indicates the anterior border of the cartilaginous scapula.

The coracoid (*co.*) is small, and is directed mainly forwards from its attachment with the scapula.

The clavicle (*cl.*) is rudimentary, and has no connection, except perhaps by ligament, with either the acromion or the sternum. The rudimentary clavicle of the Bandicoot was, I believe, first discovered by Hill, who records its occurrence in his second paper on the Placentation of *Perameles* (4).

#### *Comparative Observations.*

While the shoulder-girdle of *Dasyurus* in its early stage agrees in the main with that of the Diprotodonts, it shows one or two interesting points of difference. In *Pseudochirus* we find the coracoid forming with the sternum a distinct joint, as in *Dasyurus*; but in *Trichosurus* and *Petrogale* the cartilage of the coracoid is structurally continuous with that of the sternum. And while in *Dasyurus*, as in *Pseudochirus*, the shoulder-blade becomes free by the direct separation of the coracoid from the sternum, in *Trichosurus*, at least, the separation is brought about by the degeneration of a portion of the coracoid. In the Diprotodonts, in the early stage, the coracoid from its attachment with the scapula passes mainly inwards and backwards; in *Dasyurus* it passes inwards and slightly forwards. It seems probable that though the coracoid in *Dasyurus* is less developed than in some of the Diprotodonts, it is in a much less specialized condition, more nearly approximate to that of the primitive marsupials.

If we compare the early *Dasyurus* girdle with that of the Anomodont (fig. 4), the most striking difference is seen to be due to the great reduction of the coracoidal portion of the girdle. In the Anomodont, and almost certainly in the early Theriodont from which *Dasyurus* is descended, we find the scapula fixed by a powerful coracoid (*co.*) and precoracoid (*p.co.*). In *Dasyurus* the space between the first rib and the clavicle is very short, but is almost fully occupied by the cartilage which supports the scapula. Whether this cartilage represents the coracoid or the precoracoid of the ancestor, or both, is a question which might be argued at some length. In the paper above referred to (2) I advanced some reasons for believing that it represents the

coracoid alone, and I have seen no reason to alter my opinion. The precoracoid is apparently quite lost as a cartilage, but is probably represented by the coraco-clavicular ligament.

In the previous paper on the marsupial girdle (2) it was suggested, as a possible explanation of the development of the scapula with three borders from the ancestral form which had only two, that the spine was a new formation arising from the shifting of the cleithrum from the anterior border to the outer side of the blade. Though the spine itself can hardly be regarded as the homologue of the cleithrum, it is possible that it replaces the cleithrum, and has its position determined by the pre-existing bone. The condition of the scapula in the foetal *Dasyure* suggests an alternative possible explanation, as here the spine arises from the anterior border of the scapula, and the "prescapula" is a new formation. The difference in the two conditions may be due to the fact that in the Diprotodont the spine, by being to some extent on the side of the blade, leaves a distinct prescapular fossa in front; while in the *Dasyure* owing to the spine being attached to the anterior border of the cartilaginous blade, a prescapular fossa has to be formed by a new bony development. In the ossification of a cartilage it is exceptional for the bone to leave the limits defined by the cartilage, but another instance of it occurs in the development of the marsupial alisphenoid.

*Papers referred to in the Text.*

1. BROOM, R.—"On the Existence of a Sterno-coracoidal Articulation in a Foetal Marsupial." *Journ. Anat. & Phys.* vol. xxxix. p. 513 (1897).
2. BROOM, R.—"On the Development and Morphology of the Marsupial Shoulder-girdle." *Trans. Roy. Soc. Edinb.* vol. xxxix. pt. iii. no. 29 (1899).
3. HILL, J. P.—"On the Foetal Membranes, Placentation, and Parturition of the Native Cat (*Dasyurus viverrinus*)."  
*Anat. Anzeiger*, xviii. p. 364 (1900).
4. HILL, J. P.—"Contributions to the Embryology of the Marsupials: II. On a further Stage in the Placentation of *Perameles*." *Qu. Journ. Micr. Sci.* vol. xliii. 1899.

## EXPLANATION OF PLATE 41.

*Reference Letters.*—*a.b.c.sc.*, anterior border of cartilaginous scapula; *ac.*, acromion; *cl.*, clavicle; *cm.*, cleithrum; *co.*, coracoid; *icl.*, interclavicle; *o.st.*, omosternum; *p.co.*, precoracoid; *p.st.*, presternum; *r.*, rib; *sc.*, scapula; *sp.*, spine; *st.*, sternum; *u.t.*, undifferentiated tissue; *x.st.*, xiphisternum.

Fig. 1. *Dasyurus viverrinus*. Side view of shoulder-girdle of mammary foetus (H.L. 4 mm.). Reconstructed from sections.  $\times 50$ .

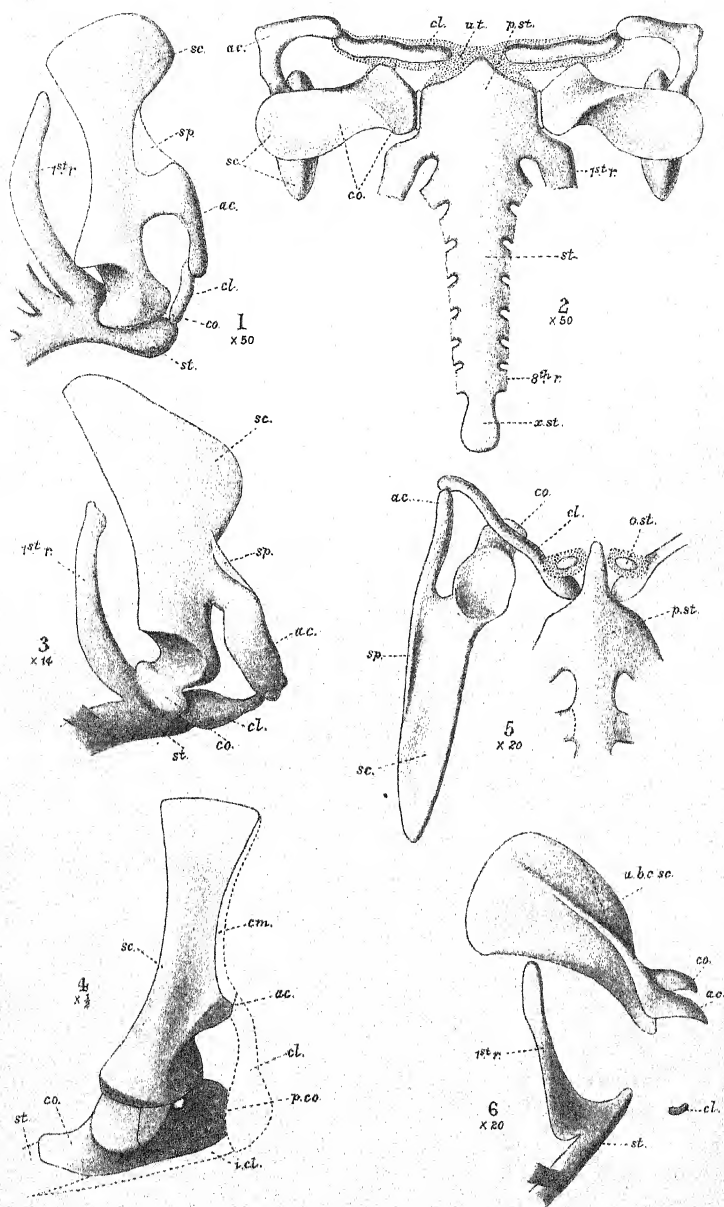
2. The same. Front view of shoulder-girdle and sternum. Reconstructed from sections.  $\times 50$ .

3. *Trichosurus vulpecula*. Side view of shoulder-girdle of mammary foetus (G.L. 17 mm.). Reconstructed from sections.  $\times 14$ .

4. *Udenodon Baini*. Side view of shoulder-girdle. Partly restored. (Coracoid and precoracoid considerably foreshortened.) Half natural size.

5. *Dasyurus viverrinus*. Front view of shoulder-girdle of mammary foetus (H.L. 8 mm.). Reconstructed from sections.  $\times 20$ .

6. *Perameles obesula*. Side view of shoulder-girdle of mammary foetus (H.L. 9 mm.). Reconstructed from sections.  $\times 20$ .



H.B. del.  
M.P. Parker lith.

Parker & West imp.

SHOULDER GIRDLES OF FŒTAL DASYURUS.



On the Anatomy of the Prosobranch Genus *Pontiothauma*, E. A. Smith. By S. PACE. (Communicated by Professor G. B. HOWES, LL.D., D.Sc., F.R.S., Sec. Linn. Soc.)

[Read 19th December, 1901.]

(PLATE 42.)

WHEN, through the kindness of Mr. E. A. Smith, of the British Museum, an opportunity was, some few years ago, afforded me to examine the two deep-sea molluscs which form the subject of the present note, I gladly availed myself of it, since the members of that fauna occupying the deeper regions of the ocean almost invariably present the morphologist with features of particular interest.

The molluscs in question formed part of the rich zoological booty which is being obtained by the Indian Marine Survey steamer 'Investigator.' Being submitted to Mr. Smith for identification, both species proved to be new to science; and, since they could not be relegated to any existing genus, Mr. Smith proposed \* for their reception the new genus *Pontiothauma*, with type-species *P. mirabile*. The affinities of *Pontiothauma*, however, appeared to be by no means clear; for, while the shell of the type-species presents a very close resemblance indeed to the whelks, the external characters of the animal seemed to be quite *sui generis*. Mr. Smith therefore asked me to examine the soft parts in order to determine the systematic position of the genus. This was done; but, since my investigations had only been based upon single specimens, which, being unique, one was naturally anxious to damage as little as possible, and further material being promised, I refrained from publishing at the time the details of my results. However, *Pontiothauma* does not appear to have been again met with; and it would therefore seem expedient to place upon record the more important of such facts as could be made out from the original material.

From the few characters which are recorded below, it will be evident that the affinities of *Pontiothauma* are with the Man-

\* Ann. & Mag. Nat. Hist. ser. 6, vol. xvi. p. 2.



gillinae\* ; but so very little has yet been published† respecting the internal anatomy of other allied forms, that it is not at present possible to assign any precise position within the subfamily to the two species dealt with in this paper. So far as our present knowledge goes, the nearest allies of these two forms, which are evidently representatives of distinct sections, would appear to be *Pleurotomella*, Verrill, and *Spergo*, Dall; and it is worthy of note that Dall‡ describes *Spergo glandiniformis*, Dall, as possessing a rostral development which would seem to be not altogether unlike that of *Pontiothauma*.

In the *Toxoglossa* generally the prestomial region is much specialized and often enormously developed; and specialization would seem to reach its maximum expression in the truly remarkable rostrum of *Pontiothauma mirabile*. It is difficult, in the absence of any information as to the habits of the animal, to suggest an adequate explanation for the structural modification observable in this form. The appearance of the rostrum in *P. mirabile* is rather suggestive of a suctorial apparatus; or, it may perhaps be that it is expressive of a habit of burrowing in the ooze and of enveloping its prey within the expanded rostral disk. Dall has suggested that the somewhat similar arrangement met with in *Spergo* is due to the habit of gorging itself with large masses of protoplasmic material, such as Foraminifera, rather than of attacking animals of a higher order. It should be stated that microscopical examination of the contents of the rhynchodæum and of the alimentary canal has failed in either species to reveal any recognizable fragments of food-material: the contents consisted apparently merely of coagulated mucus.

*PONTIOTHAUMA MIRABILE*, *E. A. Smith*. (Pl. 42. figs. 1-9.)

The single specimen, the type-specimen, upon which the following notes are based was dredged in 1250 fathoms off the Malabar coast§ by the 'Investigator.' It had been removed

\* *Pontiothauma mirabile* is by far the largest Pleurotomoid species at present known; the shell of the type-specimen has a length of 13.6 and a width of 52 centimetres.

† Dr. Dall, who has had the unique opportunity of examining the comparatively large number of deep-sea Pleurotomoids collected by the 'Albatross' and other American expeditions, has unfortunately as yet published only a few exceedingly slight and scrappy notes regarding their internal structure.

‡ Proc. U. S. Nat. Mus. vol. xvii. p. 681, pl. 24. fig. 1.

§ Ind. Mar. Survey Station, No. 125.

from its shell when I received it and was rather broken, and the tissues were so exceedingly hard as to render dissection difficult: moreover, the body-cavity had been cut into and the organs somewhat displaced.

The general appearance of the animal, as contracted in spirit, is shown by the figures (Pl. 42. figs. 1, 2, & 3). The body had evidently been entirely devoid of pigmentation. The surface of the foot is minutely granulated; but this may possibly be merely a *post-mortem* appearance.

The foot is ovate and much elevated; it is expanded and slightly bilobed in front and pointed posteriorly; and its anterior margin is very conspicuously duplicated. No trace of an operculum or opercular pad could be detected, neither was any pedal pore evident. The most remarkable feature of the external characters of this form is that to which allusion has already been made, namely, the enormous rostral development. The snout, even in the contracted state, constitutes a very considerable proportion of the whole body of the animal; and its finely wrinkled appearance suggests that it is capable of even much greater extension. It is a perfectly cylindrical structure terminating anteriorly in a large disk which bears the wide, circular rhynchostomial opening at its centre. This rostral disk appears capable of enormous expansion, its margin in the retracted condition being elaborately frilled and crenulated. The tentacles are short and apparently blunt: they are borne upon the sides of the rostrum just posterior to the origin of its terminal disk, and they are situated in a horizontal plane slightly below that of the axis of the rostrum (Pl. 42. fig. 2). No trace of eye-spots could be distinguished; it would not, however, be safe to assert that eyes are entirely absent in this form, for, not wishing to entirely destroy the unique specimen, the question of their non-existence has not been definitely decided by sectioning the head-region. Although the example dissected is a female, a rudimentary penis (P.) is present, and is situated immediately behind and a little below the right tentacle\*. The mantle-margin is somewhat thickened, and it completely encircles the body, passing round the siphon and over the foot. The siphon (S.) is solid and fleshy, it is conical in form and is devoid of appendages.

The pallial cavity can be completely subdivided into infra- and

\* The presence of a vestigial penis in the female would seem to be a not altogether uncommon occurrence among Toxoglossates.

supra-branchial chambers by means of two valvular folds of the mantle-edge. The osphradium, which is characteristically darkly coloured, measures about 10 millim. in length; it is broad, and the foliæ of its right side are much the more strongly developed. The lamellæ of the ctenidium are nearly equilateral. The terminal portions of the rectum and oviduct were missing from the specimen, and the renal organ was too fragmentary for description. The hypobranchial gland appeared but little differentiated, and there were no indications of any coloured secretion.

As will be seen from the figure (Pl. 42. fig. 3), the introvert apparatus presents greater complexity than is usually met with in the less highly specialized Prosobranchs\*. The rhynchostome is a wide, circular opening at the centre of the terminal disk of the rostrum: it is supported upon a massive cartilaginous ring. This aperture leads into a spacious cylindrical chamber (Rh.') occupying the whole interior of the rostrum. The walls of this rostral chamber are glandular and exceedingly muscular. Posteriorly it is bounded by a thick septum whose central opening is entirely closable by means of a powerful sphincter. Succeeding this is another shorter chamber (Rh'') of the same calibre as the first, but having its walls quite thin and membranous. The lumen of this post-rostral chamber was completely filled by the contracted-up proboscis (I.). Regarding the homology of these two prestomial chambers, it is probable that they together represent the simple rhynchodærum of the Rhachiglossa, rather than that the anterior cavity is to be regarded as being pre-rhynchostomial, or the posterior one as an additional development. The introvert is a large, fleshy, tapering structure with a very minute external orifice at its extremity. Its interior is quite spongy by reason of the great development of innumerable cross-folds of the inner wall which almost obliterate its lumen. The plication appears to be very irregular, although with a certain tendency towards a spiral disposition. The alimentary canal is of wide calibre throughout its simple U-shaped course. The pharyngeal bulb (Pl. 42. fig. 4, B.M.), which opens into the proboscis by a wide circular opening, is short and somewhat pear-shaped; its walls are very massive and are supported upon cartilage; the interior is finely plicated longitudinally, the plicæ

\* It is highly probable that further research will prove that the relationships of the introvert among the Toxoglossa are of an even higher order of complexity than is at present supposed.

being so disposed as to form a slight spiral gutter. The succeeding segment of the œsophagus (Oe.), which is separated from the pharyngeal bulb by an exceedingly deep cleft, is very thick-walled and somewhat laterally compressed; its interior is longitudinally plicated, but the plicæ are not so fine as are those of the pharyngeal bulb, and they become coarser towards the stomach. The stomach is expanded, and its inner wall shows several prominent longitudinal folds. The disposition of the ducts of the digestive gland appears to be similar to the condition met with in *P. abyssicola* (Pl. 42. fig. 11), and, as in that species, the intestine narrows considerably.

A well-developed Leiblein's gland of the typical "poison-gland" type is present. The gland itself and the mass of its much-convoluted duct lie to the right side of the œsophagus; but a noteworthy detail regarding this structure is that the duct enters the pharyngeal bulb upon its ventral face (Pl. 42. fig. 4, L.Gl.), whilst in the majority of Prosobranchs the œsophageal diverticulum appears to arise dorsally.

A pair of small salivary glands are associated with the minute radula-sac (Pl. 42. fig. 4, R.S.). They are compact and have a sharply recurved, narrow, distal prolongation such as occurs in *P. abyssicola* (Pl. 42. fig. 13, S.Gl.).

The radula consisted of 23 rows of the formula 1—0—1. The teeth (Pl. 42. figs. 5–9) are typically Toxoglossate; they are hollow, with subterminal external openings and have barbed extremities.

The nervous system having been torn before the specimen reached me, it is not practicable to give a satisfactory account of its characters. The cerebral ganglia, which occupy the normal position, are hardly at all separated from each other; while the pedal ganglia are situated towards the right side of the introvert sheath, and the cerebro-pedal connectives are exceptionally long and delicate.

PONTIOTHAUMA ABYSSICOLA, *E. A. Smith*. (Pl. 42. figs. 10–14.)

When describing this species Smith expressed some doubt as to the closeness of its affinity with *P. mirabile*; and the structure of the soft parts will certainly justify the removal of *P. abyssicola* from the genus *Pontiothauma*. Since, however, so little is yet known of the anatomy of other Pleurotomoids, it will perhaps be advisable to wait until further details are published regarding *Pleurotomella*, &c., before proposing another new sectional name for *Pontiothauma abyssicola*.

The single specimen (the type-specimen) examined by me had been dredged off the Kistna coast in the Bay of Bengal \* by the 'Investigator' in 753 fathoms. The animal had been extracted from its shell before I received it; and unfortunately, as also in the case of *P. mirabile*, the body-cavity had been cut into and the parts somewhat displaced.

The foot is flattened and elongate, and bluntly pointed posteriorly; anteriorly it is truncated and slightly bilobed and has the angles considerably produced. The front margin of the foot is prominently duplicated and the cleft is very deep. There is no vestige of an operculum or opercular pad and no visible pedal pore. The rostral region is not so extensively developed nor so specialized as it is in *P. mirabile*; it is not so cylindrical as it is in that species and its terminal disk is smaller and less definite. The tentacles, again, are proportionately longer than they are in the type-species: and, unlike the condition in the latter, they bear prominent black eye-spots, which are situated posteriorly upon slight elevations at their bases. The tentacles are disposed laterally to the snout, and their axes, if produced, would approximately cut that of the rostrum. The slightly thickened mantle-margin is continuous right round the body. The siphon is very short and broad, and the mantle-margin forms a wide collar around its base. The penis is large and of complex structure; it is placed rather far forward and is not covered by the mantle; its general form is indicated in the figures (Pl. 42. figs. 10 & 11, P.). The spermatid duct is broad and unconvoluted; it is completely enclosed, and its external opening is at about the middle of the lesser curvature of the penis. The body had apparently been unpigmented.

The pallial cavity of this species presents considerable similarity to what obtains in *P. mirabile*; but the hypobranchial gland is more definitely developed than it is in that form: there was no indication of any coloured secretion. The osphradium is proportionately considerably larger than it is in *P. mirabile*, and its foliæ are nearly equal. The triangular gill-laminae have their shortest edge disposed towards the rectum.

The condition of the introvert apparatus (Pl. 42. fig. 12) is less specialized than it is in *P. mirabile*. As in the latter species, the rhynchostome is furnished with a cartilaginous support; but the rhynchodæum is less completely subdivided, the transverse

\* Ind. Mar. Survey Station, No. 134.

septum of *P. mirabile* being represented by an encircling fold which is probably quite incapable of sufficient extension as to form a complete septum. The posterior chamber appears comparatively short; and the introvert in the retracted condition extends well into the anterior chamber. The introvert is a perfectly conical structure with but a minute terminal aperture; its interior is not spongy as it is in the type-species.

The alimentary canal (Pl. 42. fig. 11) has the characteristic simple U-shape and is of wide calibre throughout its course. The pharyngeal bulb is ovoidal, with thick muscular walls, and opening into the proboscis by a large circular opening. Immediately posterior to the pharynx the œsophagus, where it is encircled by the nerve-ring, becomes constricted and then again enlarges; but the constriction is not nearly so sharp as it is in *P. mirabile*. The post-neural enlargement being most marked dorsally (Pl. 42. fig. 13, Oe.), the gut in this region appears laterally compressed. The lumen of this segment of the œsophagus is almost occluded by the enormous development of the longitudinal plication of its inner wall.

The radula-sac (R.S.) is minute; its duct enters the floor of the pharyngeal bulb (B.M.) at about its middle and considerably to the right side. The teeth (Pl. 42. fig. 14) of the radula are similar to those of *P. mirabile*; but they are shorter and stouter in proportion, and the terminal barb is represented by but a slight thickening.

The salivary glands (S.Gl.) are disposed one on either side of the radula-sac, into which their ducts open. They are somewhat retort-shaped structures; their elongated, sharply recurved, distal prolongations appear to pass into the body-wall.

The poison-gland (L.Gl.) is of the normal type; but, as in *P. mirabile*, its duct, which is very long and much convoluted, enters the pharyngeal bulb ventrally at a point a little behind and somewhat to the right of the radula-sac.

The nervous system being injured, no attempt has been made to work out its detailed arrangement. It is noteworthy that, as in *P. mirabile*, the pedal ganglia lie to the right side, and that, in addition, the cerebral ganglia are much displaced so as to lie almost below the œsophagus to the left side. Contrary to the condition met with in *P. mirabile*, the cerebral and pedal ganglia are separated by but short, stout connectives.

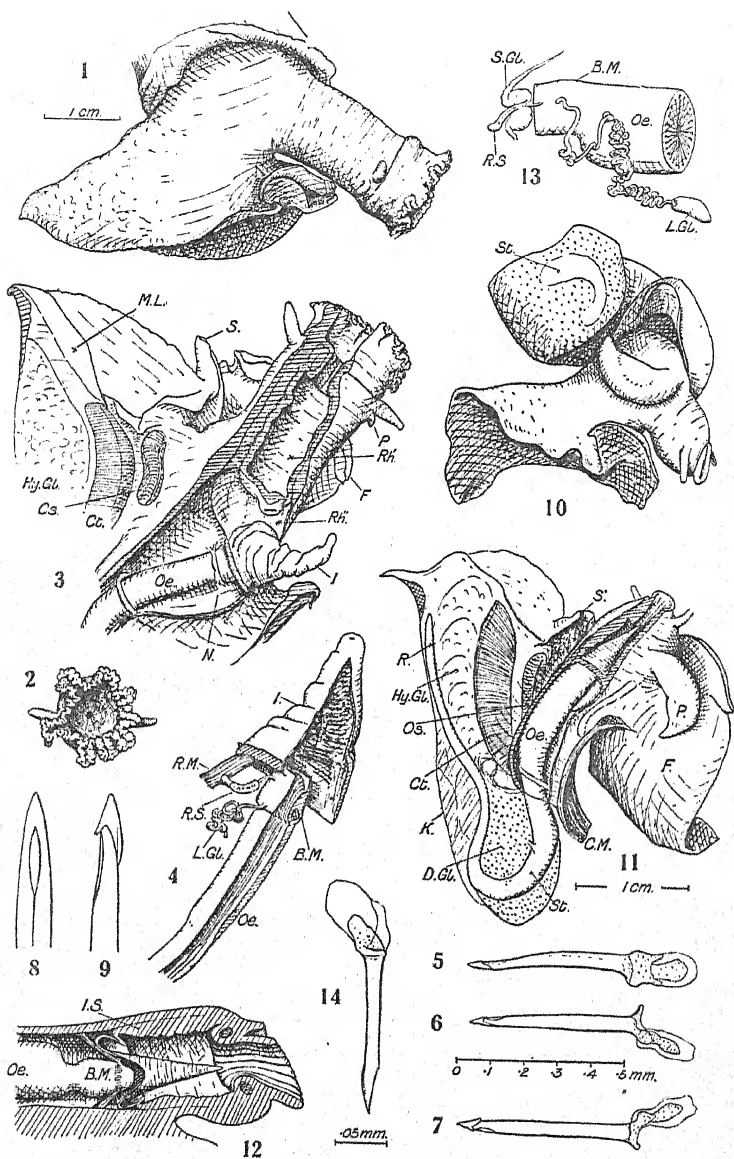
## EXPLANATION OF PLATE 42.

- Fig 1. *Pontiothauma mirabile*, Sm. External view of animal as contracted in spirit.
2. *Pontiothauma mirabile*, Sm. Rostrum as seen from the front.
3. *Pontiothauma mirabile*, Sm. General dissection of the pallial chamber, rostrum, and body-cavity; the poison-gland is omitted.
4. *Pontiothauma mirabile*, Sm. Dissection of the introvert and anterior region of the alimentary canal; the salivary glands and the distal portion of the poison-gland are omitted.
- Figs. 5, 6, 7. *Pontiothauma mirabile*, Sm. An isolated tooth of the radula viewed from different directions.
- Figs. 8, 9. *Pontiothauma mirabile*, Sm. The terminal portion of a tooth more highly magnified to show its external opening and barbed extremity.
- Fig. 10. *Pontiothauma abyssicola*, Sm. External view of the animal as preserved in spirit.
11. *Pontiothauma abyssicola*, Sm. General dissection, showing the relationships of the introvert apparatus, alimentary canal, &c. The poison-gland is seen in its undisturbed position to the right of the oesophagus.
12. *Pontiothauma abyssicola*, Sm. Median vertical section through the rostrum and anterior portion of the body-cavity; the poison-gland, radula-sac, &c. are omitted.
13. *Pontiothauma abyssicola*, Sm. Portion of the alimentary canal viewed from below, showing the relationships of the radula-sac, salivary glands, and poison-gland.
14. *Pontiothauma abyssicola*, Sm. An isolated tooth of the radula.

## Abbreviations.

B.M. Pharyngeal bulb.  
 C.M. Columnella muscle.  
 Ct. Ctenidium  
 D.Gl. Digestive gland.  
 F. Foot.  
 Hy.Gl. Hypobranchial gland.  
 I. Introvert.  
 I.S. Introvert sheath.  
 K. Renal organ.  
 L.Gl. Leiblein's gland: "poison-gland."  
 M.L. Mantle-lobe.  
 N. Central nervous system.

Oe. Oesophagus.  
 Os. Osphradium.  
 P. Penis.  
 R. Rectum.  
 R.M. Retractor muscle of the introvert.  
 R.S. Radula-sac.  
 Rh', Rh." Anterior and posterior chambers of the rhynchodaum.  
 S. Siphon.  
 S.Gl. Salivary glands.  
 St. Stomach.



ANATOMY OF PONTIOTHAUMA.





On *Obesiella lyonsiellæ*, a new Genus of Copepod Crustacean.

By W. G. RIDEWOOD, D.Sc., F.L.S.

[Read 19th June, 1902.]

THE specimens described in this paper were taken from the suprabranchial cavities of a single specimen of the deep-sea Lamellibranch *Lyonsiella*, dredged by the 'Challenger' from a depth of 1600 fathoms at Station 147 (off Crozet Is., W.N.W. of Kerguelen Is.).

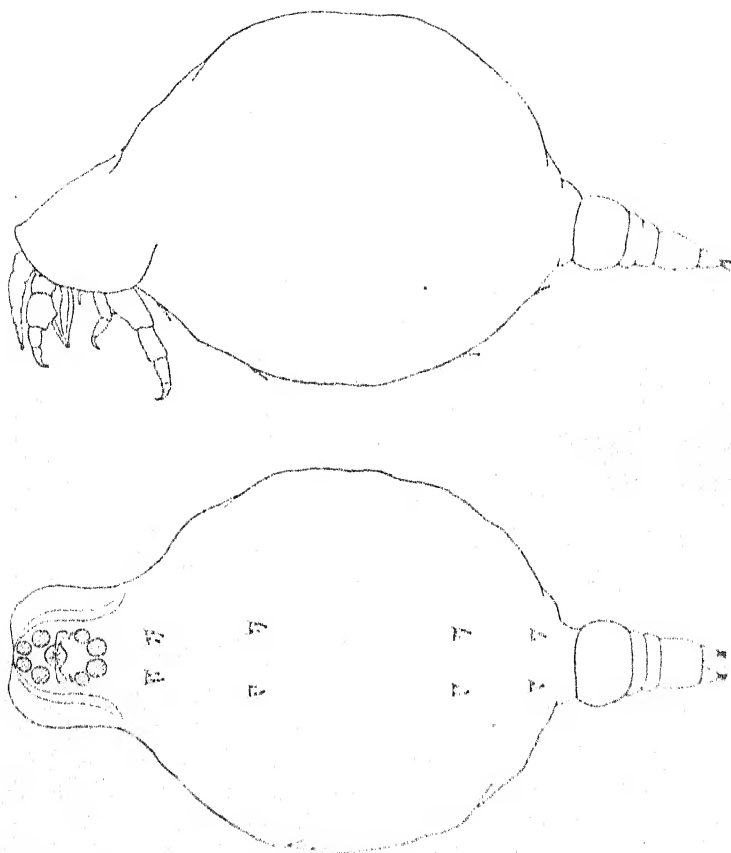
All the specimens were females. Seven of them were perfect, but there were fragments of five more, so that there must have been twelve in the two suprabranchial cavities. They were so closely packed that the passage of water through the suprabranchial cavities must have been a matter of considerable difficulty. Five of the specimens remain preserved in alcohol, and these and the nine microscope-slides prepared from the others are in the Natural History Museum, London. The specimens measured 2·3 mm. in total length, and 1·4 mm. in maximum breadth across the thorax.

Their most remarkable feature is the great inflation and loss of external segmentation of the thoracic region, and the reduction in size of the thoracic appendages. The head has the appearance of being provided with a hood, owing to the presence of a dependent flap on each side. There are no eyes. Six pairs of cephalic appendages are present, and four thoracic. The abdomen is indistinctly divided into four segments, the last bearing a pair of caudal rami, short and papilliform, with four or five short setæ. The mouth is extremely small, and set upon the pointed summit of an oral cone, into the conformation of the sides of which the third pair of appendages enter.

The first pair of appendages (antennæ) are of moderate size, flexible, and indistinctly segmented. The terminal fourth is rod-like, sometimes bent upon the rest of the limb, and terminated by a few short setæ.

The second appendages (second antennæ) are slightly longer than the first. There are five segments, the proximal one being mostly concealed in a side view by the margin of the hood. The terminal joint is a strong curved claw.

The third appendages (mandibles) are greatly reduced, being represented only by their basal segment, which extends inwards and downwards and fuses with the sides of the oral cone.



*Obesiella lyonsiella*.—From the left side and from below.  $\times 38$ .

In the lower figure the cephalic appendages are represented as cut off short.

The fourth appendages (maxillæ) are very small. The inner ramus is a flexible palp, and is terminated by two or three setæ; the outer has the form of a shallow eminence rising from the end of the ridge which represents the basal portion of the appendage. This is the only cephalic appendage in which any trace of the outer ramus is discernible.

The fifth appendages (first maxillipedes) are three-jointed, the terminal joint being a curved claw. They are the smallest of the three pairs of clawed appendages.

The sixth appendages (second maxillipedes) are the longest of the head appendages. There are four segments, the terminal one having the form of a sharp claw and being incompletely divided across.

The four pairs of thoracic appendages are biramous, but very small. The outer ramus is two-jointed, the proximal being larger than the distal joint. The jointing is not well marked in the two posterior pairs. Three or four short setæ occur at the tip of each outer ramus.

The inner rami, which arise from a basal ridge at a little distance from the outer ramii, are also two-jointed. In the first thoracic appendages the distal joint is larger than the proximal and bears a few setæ. There is a papilla on the basal segment of the appendage lying to the inner side of the inner ramus. In the second pair the distal joint is larger than the proximal and has no setæ. In the third and fourth pairs the terminal joint is much smaller than the proximal and is incompletely divided from it. It has no setæ.

The genus falls naturally within the family Ascomyzontidæ. It differs from *Nicothoë*, Aud., in having the mouth set on a conical projection. It resembles *Ascomyzon*, Thorell, and *Uperogcos*, Hesse, in having five joints to the second cephalic appendages, and differs from *Asterocheres*, Boeck, which has four joints, and from *Dyspontius*, Thorell, *Artotrogus*, Boeck, *Platythorax*, Hesse, and *Ceratrighodes*, Hesse, which have three. It differs from *Uperogcos* and resembles *Ascomyzon* in that the oral cone is long and the second cephalic appendages are not antenniform; but it differs from *Ascomyzon* in that the first cephalic appendages are of moderate length and indistinctly segmented, whereas in *Ascomyzon* they are long and 20-jointed.

The extreme reduction of the four pairs of thoracic appendages is doubtless intimately associated with the swelling of the thorax, and is probably not shared by the male.

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New and Old *Phalangiidae* from the Indian Region. By  
C. WITH, Copenhagen. (Communicated by H. J. HANSEN,  
F.M.L.S.)

[Read 20th November, 1902.]

#### INTRODUCTION AND LIST OF SPECIES.

DRS. H. J. HANSEN and W. SÖRENSEN received the Indian Phalangiidae herein described from the Indian Museum, Calcutta, by the kindness of Dr. A. Alcock, F.R.S., Curator of that Institution, to which they will ultimately be returned. Dr. Sørensen made some preliminary studies, but as he had no time to finish them, he and Dr. Hansen left the collection to me to work out. I take this opportunity of tendering these two gentlemen, but especially Dr. Hansen, my best thanks, for their kindness in assisting me in this and in other tasks. As will be seen from the following, I have had occasion to extend my knowledge by studying the animals of this group preserved in the Zoological Museum of Copenhagen, which Dr. Meinert has placed at my disposal. The greater part of this collection embraces Thorell's original species.

The genus *Gagrella*, the type of the subfamily Gagrellinae, was founded by Stoliczka in 1869. Different naturalists have since his time contributed to the knowledge of the Indian harvestmen, but none more than the late T. Thorell. He described most of the recognized species and described them very well. His several papers form the basis for work on this section of the Indian fauna. Some of his genera are not very well founded, but we must remember that he based them on a relatively scanty material.

The following is a list of the Phalangiidae from the Indian continent and adjacent islands and certain other localities.

#### NEW GUINEA.

*Gagrella Albertisii*, Thor.; *G. Doleschallii*, Thor.; *G. xanthostoma*, Thor.

#### PHILIPPINES.

*Zaleptus inermis*, Sim.; *Gagrella elegans*, Sim.; *G. obscura*, Sim.;  
*G. luzonica*, Loman.

## AMBOINA.

*Gagrella amboinensis*, Thor.

## BORNEO.

*Zaleptus trichopus*, Thor.; *Gagrella insculpta*, Pocock; *G. longipalpis*, Thor.; *G. scrobiculata*, Thor.; *Marthana columnaris*, Thor.

## FLORES.

*Gagrella atra*, Loman; *G. tennis*, Loman.

## ARU.

*Gagrella bipeltata*, Thor.

## JAVA.

*Zaleptus trichopus*, Thor.; *Gagrella insculpta*, Pocock; *G. albicava*, Loman; *G. (Melanopa) conspersa*, Thor.; *G. (Melanopa) Aurivillii*, Thor.; *G. celerrima*, Loman; *G. Lomanii*, Thor.; *G. ramicornis*, Thor.; *G. sepiu*, Loman; *G. testacea*, Thor.; *G. variegata*, Dol.; *G. vestita*, Thor.; *G. viridis*, Dol.; *G. volcanica*, Dol.; *G. simplex*, Lom.; *Marthana cuspidata*, Loman.

## SUMATRA.

*Ceratobunus quidricornis*, Thor.; *Zaleptus ramosus*, Thor.; *Z. simplex*, Thor.; *Gagrella acuarua*, Thor.; *G. albitarsis*, Sim.; *G. concinna*, Thor.; *G. ephippiata*, Thor.; *G. Hasseltii*, Thor.; *G. monticola*, Thor.; *G. pullata*, Thor.; *Platybunus minus*, Loman.

## NIAS.

*Gagrella niasensis*, Thor.

## NICOBARS.

*Gagrella dentata*, n. sp.; *G. imperator*, n. sp.

## ANDAMANS.

*Gagrella imperator* var. *unispinosa*, n. sp.

## CAMBODJA.

*Systenocentrus quinquedentatus*, Sim.

## LOWER BURMA AND MALAY PENINSULA.

*Zaleptus festivus*, Thor.; *Z. subcupreus*, Thor.; *Z. sulphureus*, Thor.; *Gagrella binotata*, Sim.; *G. cervina*, Sim.; *G. Fée*, Thor.:

*G. lepida*, Thor.; *G. quadrivittata*, Sim.; *G. Stoliczkei*, n. sp.; *G. bicornigera*, Sim.; *G. senigranosa*, Sim.; *G. patalungensis*, Sim.; *G. illusa*, Sim.; *G. biseriata*, Sim.; *G. atrorubra*, Sim.; *Verpulus spumatus*, Sim.

#### UPPER BURMA.

*Arthrocentrus atratus*, Thor.; *Ceratobunus annulatus*, Thor.; *C. bimaculatus*, Thor.; *C. lugubris*, Thor.; *Gagrella anescens*, Thor.; *G. armillata*, Thor.; *G. chaetopus*, Thor.; *G. crebca*, Thor.; *G. histrionica*, Thor.; *G. laticlavata*, Thor.; *G. minor*, Thor.; *G. mirabilis*, n. sp.; *G. nocticolor*, Thor.; *G. (Melanopa) plebeja*, Thor.; *G. sordidata*, Thor.; *G. spinulosa*, Thor.; *G. (Melanopa) tristis*, Thor.; *Scotomenia cetrata*, Thor.; *Oncobunus galeatus*, Thor.

#### INDIA.

*Hypsibunus vigilans*, n. sp.; *Ceratobunus brevipes*, n. sp.; *C. calcuttensis*, n. sp.; *C. pulchra*, n. sp.; *Zaleptus fuscus*, n. sp.; *Z. hirsutus*, n. sp.; *Z. Thorellii*, n. sp.; *Gagrella atrata*, Stol.; *Zaleptus minutus*, n. sp.; *Gagrella crux*, n. sp.; *G. fragilis*, n. sp.; *G. Hansenii*, n. sp.; *G. hirta*, n. sp.; *G. Maindroni*, Sim.; *G. nobilis*, n. sp.; *G. signata*, Stol.; *G. triangularis*, n. sp.; *G. varians*, n. sp.; *Syleus niger*, C. L. Koch.

#### CEYLON.

*Gagrella bispinosa*, Karsch; *G. ceylonensis*, Karsch; *Pseudarthromerus spinarius*, Karsch.

#### CHINA.

*Gagrella splendens*, n. sp.; *G. ferruginea*, Lom.

#### JAPAN.

*Gagrella ferruginea*, Lom.

#### LOCALITY UNKNOWN.

*Hypsibunus diadematus*, Thor.; *Gagrella bidentata*, Thor.; *G. docilis*, Loman (Corral?); *G. flavimaculata*, n. sp.; *G. monacantha*, Herbst; *Marthana turrita*, Thor.

#### DISTRIBUTION.

So far as we can see, the Indian continent and islands seem to a certain degree to be characterized by the *Gagrellineæ*. Other *Opiliones palpotares* are also known from India, viz.,

*Platybunus mirus*, Lom., from Sumatra, and *Pseudarthromerus spurius*, Karsch, from Ceylon; but since only a part, and perhaps a very small part, of the existing Indian species are known and hardly any from the neighbouring countries, and since the subfamily is a badly defined one, we must be careful not to over-estimate the importance of the geographical facts, and must particularly avoid drawing conclusions from them.

Dr. J. C. C. Loman has unfortunately done this. He writes in his paper ("Opilioniden der Sammlung Plate," Zool. Jb. Syst. 1899):—"Es ist hier auffällig, wie die Opilioniden aus der europäischen Familie der Phalangioideæ nicht in der unteren heißen Zone gefunden, sondern alle im Gebirge gesammelt wird. Ähnliches lässt sich von tropischen Afrika und Amerika zur Zeit freilich nur vermuthen, da genaue Höhenangaben fast nie vorliegen."

Certain facts seem now to contradict his first conclusion, as follows:—

(1) *Gagrella atrata*, Stol., and *Ceratobunus calcuttensis* are found in the neighbourhood of Calcutta, which certainly may be called a low-country locality.

(2) *Gagrella dentata* and *G. imperator* were taken by the 'Galathea' Expedition on the "Large" and the "Little" Nicobars. But the description of the voyage seems to prove that the members of the expedition did not penetrate far into the interior of the islands, and not at all into the mountains.

Loman's conclusion about the Indian Phalangioideæ must be regarded as too hastily formed and erroneous, and his last supposition is also incorrect, at least with regard to America, since Dr. Sørensen has informed me that he has taken specimens of the genus *Liobunum* near Riacho del Oro in Gran Chaco (Argentina), which is a plain.

#### CHARACTERS OF THE GAGRELLINÆ.

The subfamily *Gagrellinæ* was established by Thorell in 1889. The main differences between this section and the *Sclerosomatinae* (Sim.) are the following:—The cephalothorax and the first dorsal segments of the abdomen form in the *Sclerosomatinae* one hard scutum and the apertures of the stink-glands are not visible from above.

In the *Gagrellinæ*, on the other hand, only the abdominal segments are united to a scutum and the stink-gland apertures are visible from above.



The *Gagrellinæ* also differ from the *Phalangiinæ*, Sim., according to Thorell (10. p. 607), "quod tegumenta duriuscula habent, cephalothoracem e duabus partibus articulatione separatis compositum et etiam ab abdominis scuto dorsali, quod e 5 vel 6 segmentis coalitum est, articulatione divisum, coxas vero in marginibus serie densa lamellarum parvarum crenulatas." But these characters are not always limited to the *Gagrellinæ*.

The skin of *Liobunum rupestre*, Herbst, is rather hard, and the last segment of the cephalothorax is well separated, both from the rest of the cephalothorax and from the abdomen. The first segments of the abdomen are indistinct in *Liobunum rupestre*. The cephalothorax of species of *Acantholophus* is very distinctly separated into two parts. At least some species of *Liobunum* have marginal rows of teeth on the coxæ (viz., *L. rotundum*, Ltr., see Simon, 21. p. 173), and one species has them so well developed, that Simon has formed the genus *Cosmobunus* on this character (Simon, 21. p. 189).

Some other differences between the two subfamilies may also be mentioned.

The labrum of the *Gagrellinæ* is long and slender, in the *Phalangiinæ* it is triangular: *Liobunum rupestre* being in this respect most nearly akin to *Gagrella*. The procursus frontales of the *Gagrellinæ* are well developed and toothed, while they are small and smooth in the *Phalangiinæ*; but *Gagrella splendens*, for example, is in this respect similar to the last.

It seems thus a little difficult to draw a sharp line between the two subfamilies.

The *Phalangiinæ* are divided into two groups: ( $\alpha$ ) species similar to *Liobunum*, and ( $\beta$ ) those which are most akin to *Phalangium*. The main characters of *Liobunum* are the small openings of the stink-glands and the shape of the penis; and the *Gagrellinæ* have both these characters in common with them (see Thorell, 10, and Loman, 14). Also in other characters they are similar to each other, though there are features common to *Liobunum* and *Mitopus*, Thor., viz., the presence of a tooth near the base of the antenna and the false articulations of the second tibia.

The following points of similarity are certainly not of very great importance, since they vary within the limits of the different genera and species; but they are perhaps the expression of a certain degree of relationship. The coxæ are toothed in at

least some species of *Liobunum*. The procursus maxillaris internus is well developed and two-branched in the *Gagrellinæ* and *Liobunum*, while in *Phalangium* it is a slightly marked projection.

It is thus evident that the limitations of the two subfamilies *Gagrellinæ* and *Phalangiinæ* fluctuate, and that *Liobunum* forms a connecting-link between the two.

Since I am not the most competent person to judge where the limits are to be drawn, and since Drs. Sörensen and Hansen have called my attention to several of the aforementioned facts, which make the subfamily of the *Gagrellinæ* an unnatural one, I would refer to the forthcoming paper, in which they record these and other important results of their investigations.

#### ON THE SYSTEMATIC AND SEXUAL CHARACTERS.

The shape of the cephalothorax varies but little. The last segment is always separated by deep articulations both from the rest of the cephalothorax and from the abdomen. The enultimate segment may be well marked, but it is never limited by an articulation in front. The tubercle is placed nearer or farther from the abdomen in relation to the development of the aforementioned segments, and the segments of the scutum are marked by transverse grooves on each side. The scutum is either unarmed or provided with a spine or tubercle. There is ordinarily one spine on the second segment; more rarely there is one on the first as well. In *Scotomenia* there is a tubercle on the first. The number of the spines is a very characteristic specific feature, but their generic value is relatively slight, and it seems to me impossible to found good genera upon their development, as Thorell has done. To this subject, however, I shall return. Their number varies also according to the species. In *Zaleptus minutus*, n. sp., there is occasionally an abdominal tubercle. *Gagrella imperator*, n. sp., has either two long or one long and one short spine.

The granulation of the body is variable, but of some systematic value. The body is very seldom pitted as it is in *G. sordidata*, Th., and ordinarily it is more or less granular. The granules are more or less crowded, larger or smaller, and flattish. Dorsally the scutum is almost always well granulated, the other parts more or less so; while the free ventral segments, with the exception of the lateral parts and the articulations, are generally smooth.

*Gagrella dentata*, n. sp., is almost completely smooth, but *G. (Melanopa) tristis* (Thor.) is granular all over. The sides of the cephalothorax are sometimes spinous (*G. spinulosa*, Thor.). The frontal eminence is in *Gagrella dentata* provided with a tooth directed forwards and upwards; in *G. sepia* (Lam.) there is a row of large granules in this position. The procursus frontales differ very much, but their shape has no specific value. The openings of the stink-glands are distinct and small. The ocular tubercle has a very great systematic value, at least within the limits of the genera. It is high or low; and the diameter of the eyes is either smaller or larger than the distance between their lower edges and its base. Its armature varies more or less, and must therefore be considered with caution (cf., for ex., *Hypsibunus vigilans* and *Ceratobunus brevipes*).

The basal joint of the antenna is smooth or granular above. The "fingers" are provided with a larger tooth near the base and a crenulated edge, but their armature is sometimes a little different from what is customary, as, for example, in *G. hirta* and *G. triangularis*, in which one or both "fingers" are provided with a large tooth near the middle, with a succeeding smooth area and the usual crenulation.

The labrum (epistoma) is slender and pointed; it is sometimes in *G. triangularis* enlarged towards its extremity. The procursus maxillares are to a certain degree different in the species. The length and armature of the palps are important features, but on the contrary, while I do not think that the variations in length or absence of the apophysis of the patella are of much significance, I attach special value to the sexual differences of the palp. Such species as *Gagrella flavimaculata* and *G. splendens* can be very well distinguished by the palps of the males.

The length of the legs differs very much in the species and is a matter of importance.

The false articulations of the 2nd pair of tibiæ are often well developed, and the femora of these appendages in *Scotomenia cetrata*, Thor., and *Ceratobunus brevipes* have false articulations also. I believe, however, that Karsch (13. p. 308) much over-estimates the importance of this character, by founding his genus *Pseudarthromerus* upon it.

The colour has, of course, a certain systematic importance.

The difference between the males and the females is not so marked as in many other Phalangiidæ. It is difficult to distinguish

the sexes in the young animals, but in the fullgrown it is generally easy. The genital plate of the female is much more enlarged towards the base than that of the male, in which the sides are more nearly parallel.

The tarsi of the palps in the females are almost always smooth; those of the males are sometimes (ex. *Gagrella plebeia*, Thor., and *Zaleptus festivus*, Thor.) smooth, but generally provided with one or two rows of teeth or granules. Thorell has noticed this character in the male of *Ceratobunus annulatus*, Th. (10. p. 616). Two species (*Gagrella triangularis* and *G. flavimaculata*) have two rows of tarsal teeth (cf. *infra*, pp. 499–500). A great number have one single row along the inner lower edge, which begins near the base and extends over the distal two-thirds. The teeth or granules vary in number from 25 to 50 in different species and specimens, and are placed either close together or apart. In the latter case (ex. *Gag. ænescens*, Th., and *G. splendens*, n. sp.) the proximal teeth are always less separated than the distal.

The tibiae of the males are, at least in two species (*G. ænescens*, Thor., and *G. splendens*, n. sp.), much thicker than those of the females.

While the younger females and the males are similar in their general aspect, the pregnant females are very characteristic. The whole body is much dilated and the segments, on account of this, are well separated from each other. This is chiefly noticeable upon the dorsal surface, as the tergal plates are granular, and the articulations smooth and often lighter in colour. The articulations between the dorsal and ventral segments are often so high, that the scutum has the appearance of a cap, which covers the top of the abdomen.

On the articulations between the dorsal and ventral segments small, more chitinous pieces are present. The ventral segments are separated into a central and two lateral parts, which are more or less distinct from one another, the lateral part of the first free ventral segment being the most developed, those following becoming gradually smaller.

The lateral parts are often granular. There is ordinarily no difference between the central and the lateral parts of the ventral segments in the males. *Gagrella Hansenii*, n. sp., is, however, an exception to this rule.

The colour and the length of the legs are sometimes a little different in the males and the females.

As will be seen later on, I am very doubtful as to the real systematic value of most of Thorell's genera, if the claim to systematic distinction be regarded as an expression of natural relationship. In the future, it may or may not be possible to establish good genera on the old characters or new ones. If it be not possible to do so, the only means of forming a system will be by comparing species, to find out their nearest relationships with regard to all characters and the facts of geographical distribution. But to do this we must have much more material.

#### DESCRIPTION OF GENERA AND SPECIES.

The genera *Hypsibunus*, Th. 1891, *Ceratobunus*, Th. 1889, and *Zaleptus*, Th. 1876, were each established by Thorell, and very well founded for his time; but when the Indian species are taken into account, they certainly fail. Let us first examine the difference between *Zaleptus* on the one hand, and *Gagrella* and *Melanopa* &c. on the other. The scutum of the first is always unarmed; that of the latter is provided with a spine or tubercle. The legs of *Zaleptus* are more or less long; the legs of *Gagrella* and *Scotomenia* are excessively long or short. *Zaleptus minutus*, n. sp., however, has rather short legs, and one of three specimens is provided with a very small, but distinct abdominal tubercle. The legs of *Ceratobunus brevipes* are almost as short as those of *Scotomenia*. The genus *Zaleptus* cannot be regarded as a natural one. The difference between *Zaleptus* and *Ceratobunus* lies in the dentition of the tubercle. *Ceratobunus* has, according to Thorell, two or four thorns on the tubercle, whereas the tubercle of *Ceratobunus brevipes* bears four or six; and as *Hypsibunus vigilans* has two or none, the definition becomes unsatisfactory (comp. Thorell, 12. p. 678).

The ocular tubercle of *Hypsibunus* is as high as broad; in *Zaleptus* and *Ceratobunus* it is lower; but since *Zaleptus hirsutus*, n. sp., and *Gagrella nobilis*, n. sp., have the tubercle almost as high as broad, I do not think that this character has much value.

Although I am convinced that the genera named have no systematic importance, I retain them for practical purposes.

#### *HYPSIBUNUS*, Thorell, 1891.

*H. diadematus*, Th.—Tubercle armed with five teeth. Colour

black, spotted with white. The second pair of tibiæ are without white points.

*HYPSIBUNUS VIGILANS*, n. sp.

♂. Cephalothorax almost semicircular. The body is horizontal from the ocular tubercle to the fourth abdominal segment; but from that point it slopes abruptly downwards posteriorly. The body is granular above, but the cephalothorax and coxæ are less so. Free ventral segments smooth. Lamina frontalis well developed and separated into a right and left part by the short and toothed procursus frontales. Ocular tubercle, seen from the side, once and a fourth as high as long; its anterior face is perpendicular and higher than the posterior, its summit is beset with a few granules and in the middle by a stout obtuse perpendicular spine as long as the diameter of the eyes. Tubercle, seen from the front, at least as high as broad. Diameter of the eyes larger than the distance between them, and one-third of the distance between the lower edge of the eyes and the base of the tubercle. Basal joint of the antenna smooth. Procursus maxillaris internus two-branched. Femora of the palps spinous below; patellæ enlarged towards their ends and granular. Tibiæ twice as long as broad. Tarsi, as is usual in the males, armed with a row of small conical teeth near the inner edge. Femora of the legs spinous, and the legs very strong and long.

Femur I=12, II=22 (c. 100), III=12, IV=15 mm. Second joint of the antenna  $1\frac{1}{4}$  mm. long. Length of the body 5 mm.

Colour of the upper surface blackish. Cephalothorax reddish brown in front of the tubercle. Two longitudinal bands between the tubercle and the front are most marked, and separated by a narrow black band, which is broadest in front. Lamina frontalis spotted with yellow. Sternal plate red with black margins. Free ventral segments yellow, with indistinct black spots. Antennæ and palps yellowish. Legs blackish brown, but lighter towards their ends. Articulations between the coxæ and the trochanters white; and the ends of the first pair of tibiæ are annulated with white.

Tubercle of the other specimen without eminence. Scutum bears a row of reddish-brown indistinct spots, and the black spots of the free ventral segments are distinct.

Two males from Silcuri.

CERATOBUNUS, *Thorell*, 1889.

- a.* Femora of the first pair of legs more than three times as long as the second joint of the antennæ.
- a*<sup>1</sup>. Tubercle provided with two horns.
- a*<sup>2</sup>. Femora with white rings; cephalothorax without white spots ..... *annulatus.*
- b*<sup>2</sup>. Femora without white rings; cephalothorax spotted with white.
- a*<sup>3</sup>. Scutum with a red longitudinal band ..... *bimaculatus.*
- b*<sup>3</sup>. Scutum black, without band ..... *lugubris.*
- b*<sup>1</sup>. Tubercle with four horns.
- a*<sup>4</sup>. Points of horns biramous ..... *pulcher.*
- b*<sup>4</sup>. Horns not biramous ..... *calcuttensis.*
- b.* Femora of first pair of legs only three times as long as second joint of antennæ ..... *brevipes.*

CERATOBUNUS ANNULATUS, *Thor.* 1889.

*Thorell*, (10) p. 616.

As observed by *Thorell*, the tarsi of the palps are in the males provided with the usual row of granules.

CERATOBUNUS BIMACULATUS, *Thor.*

*Thorell*, (10) 1889, p. 619.

Tarsi of the palps of the males provided with the usual row of granules, which in the proximal half are placed close to each other, in the distal farther apart.

CERATOBUNUS LUGUBRIS, *Thor.*

*Thorell*, (10) 1889, p. 621.

## CERATOBUNUS PULCHER, n. sp.

Cephalothorax semicircular. The scutum is almost horizontal. The body, including the lamina frontalis and the base of the tubercle, densely granular. Free ventral segments smooth. The lamina frontalis is undeveloped; the procursus frontales are small, united and spinous.

Tubercle as high as long, and almost as high as broad; it is convex and bears two horns, directed forwards and backwards. They are both two-branched, but the branches are short. The foremost twice as long as the diameter of the eyes, the hindmost a little shorter than this. The tubercle is smooth and without groove. The diameter of the eyes is shorter than the distance

between the eyes, and than the space between the lower edge of the eyes and the base of the tubercle.

The basal joint of the antenna is granular. The femora of the palps are toothed below; the patellæ are enlarged towards their extremities and provided with a small apophysis. The tibiæ are twice and a half as long as broad. The femora of the legs are almost smooth.

Femur I=7, II=13, III?, IV=9½ mm. Body 3½ mm. The second joint of the antenna ¾ mm.

The body is black; the ventral segments are covered with a grey waxy material. The scutum is provided with a distinct red-brown, almost rhomboidal spot. The front part of the cephalothorax is on each side provided with a distinct white waxy spot. On each side of the abdomen behind the scutum there is placed a smaller similar spot. The antennæ and palps are yellow; the legs are light brown.

One specimen from Punkabari.

*CERATOBUNUS CALCUTTENSIS*, n. sp.

♀. Cephalothorax trapezoid, and body much raised towards the fourth segment of the scutum; behind this it slopes gradually downwards. The anterior third of the ventral segments (central parts) is raised and well separated from the rest. Body finely granular above. Coxæ with fewer and larger granules. Lateral parts of the first ventral segment also granular. Lamina frontalis not separated from the small and stout procursus frontales.

Tubercle, seen from the side, as long as high, and higher in front, and its sides are convex. Seen from the front it is almost as high as broad. The top, which is ungrooved, is crested with two long obtuse thorns on each side; the anterior is longer and directed forwards, the hindmost backwards. The eyes are small, and their diameter is less than the distance between the eyes and than the distance between their lower edge and the base of the tubercle.

Antennæ granular above. Procursus maxillaris internus two-branched, the upper branch slender, the lower very short and broad, its lower edge granular. Femora, patellæ, and tibiæ of the palps toothed, especially the femora, below; the patellæ with a small inner apophysis. Tibiæ twice and a half as long as broad, and the femora of the legs spinous.



Femur I=5 (leg)=22, II=11 (c. 45), III=5 (22), IV=8 (33½) mm. Body 4¼ mm. Second joint of the antenna ¾ mm. long.

Colour blackish brown; ventral segments reddish. Hindmost part of the abdomen has a reddish spot on each side. Antennæ yellow; palps brown with yellowish tibiæ and patellæ. Legs red-brown with darker patellæ.

One female from Calcutta.

*CERATOBUNUS BREVIPIES*, n. sp.

♀. Cephalothorax triangular. Abdomen almost straight; the limitation of the scutum behind is not sharp, since the first free segment is more or less united with it. Body granular with the exception of the free ventral segments. Cephalothorax has the usual depressed triangle with curved depressions. Lamina and procursus frontales small. The tubercle is low, convex, as high as long; seen from the front, it is broader than high, and not narrowed at its base; its top is not grooved, but each side has an anterior and a posterior thorn, as long as the diameter of the eyes. Diameter of the eyes a little larger than the distance between them and than that from their lower edge to the base.

Basal joint of the antennæ granular above. Femora of the palps toothed below; the patellæ have a small apophysis, and chiefly the inner side is toothed. Tibiæ twice as long as broad, and provided on their inner side with teeth. Tarsi much longer than the femora. Femora have 3 to 5 false articulations and small teeth.

Femur I=3 (leg=14), II=5½ (27), III=3 (14), IV=5 mm. Body 4 mm. Second joint of the antenna 1 mm. in length.

Colour more or less yellowish-red with darker spots. A longitudinal lighter indistinct band runs along the abdomen; the space between the eyes is yellow. A narrow brown band between the tubercle and the front. Cephalothorax, and especially its last segment, beset with dark spots. Margins of the scutum and transverse spots black. Underside more brown with a transverse row of yellow spots on each segment. Antennæ and the palps yellow. Legs brown or yellowish, with small paler rings.

Tubercle of one specimen has on the right side a third thorn behind the second, on the left only a small tooth. The colour of this is darker than in the two other specimens.

Three females from Calcutta.

*ZALEPTUS, Thorell, 1876.*

- a.* Femora of legs either not hairy or beset only by few hairs.
- a*<sup>1</sup>. Palps not smooth.
- a*<sup>2</sup>. Legs very long.
- a*<sup>3</sup>. No yellow waxy spots on cephalothorax; tubercle smooth; colour yellowish white, with darker spots and a metallic appearance. *subcupreus.*
- b*<sup>3</sup>. Body more or less covered with a yellow waxy material, and the tubercle granular.
- a*<sup>4</sup>. Tibiæ white, and annulated at their points. Below the body bears a darker longitudinal band; cephalothorax in front with two yellow waxy spots. . . . . *festivus.*
- b*<sup>4</sup>. Tibiæ not annulated with white. Almost the whole body covered with a yellow waxy material . . . . . *sulphureus.*
- b*<sup>2</sup>. Legs rather short.
- a*<sup>5</sup>. Diameter of the eyes twice as long as the distance between their lower edge and the base of the tubercle. Tibiæ of palps twice as long as broad . . . . . *fuscus.*
- b*<sup>5</sup>. Diameter of the eyes equal to the distance from their lower edge to the base. Tibiæ of palps three times as long as broad . . . . . *Thorellii.*
- b*<sup>1</sup>. Palps smooth . . . . . *minutus.*
- b.* Femora of the legs hairy . . . . . *hirsutus.*

*ZALEPTUS SUBCUPREUS, Thor. 1889.*

Thorell, (10) 1889, p. 609.

The row of tarsal granules is wanting in the males.

Two specimens from Kollads Salween Hill and Hungdarow.

*ZALEPTUS FESTIVUS, Thor. 1889.*

Thorell, (10) 1889, p. 611.

The tarsal row of granules is wanting in the males.

*ZALEPTUS SULPHUREUS, Thor. 1889.*

Thorell, (10) 1889, p. 614.

Hungdarow.

*ZALEPTUS FUSCUS, n. sp.*

♀. Cephalothorax almost semicircular. Last two segments of the cephalothorax well developed. Body raised towards the fourth abdominal segment, and the foremost third of the free ventral

segments is more raised than the rest, and the body is granular with exception of these.

Grooves between the segments of the scutum well marked. The cephalothorax has a well-marked depressed triangle.

Frontal eminence distinct; procursus frontales well separated, obtuse, and dentate. The tubercle is rather low, and seen from the side a little longer than high. The crest is convex. In front it is much narrower towards its base and much broader than high above. The top is deeply grooved and bears in front one single obtuse tooth. Diameter of the eyes as large as the distance between them, and twice as large as the distance between their lower edge and the base of the tubercle.

Basal joint of the antenna smooth. Procursus maxillarius internus almost square, as the usual lower branch is missing. The upper branch is pale and slender. The lower edge is granular. Femora of the palps shorter than the tarsi and spinous below and above. Patellæ a little broader towards their points and strongly toothed. Tibiæ twice as long as broad and inwardly spinous. Femora of the legs spinous.

F. I= $6\frac{3}{4}$  (leg=30), II= $11\frac{1}{2}$  (54), III= $6\frac{1}{2}$  ( $28\frac{1}{2}$ ), IV (?). Body  $5\frac{1}{2}$  mm. The second joint of the antenna measures  $1\frac{1}{4}$  mm.

Colour of the body black. Space between the eyes and the ventral segments lighter. Articulations yellow. Antennæ, the tarsi, and the points of the tibiæ of the palps yellow. Legs blackish, with the base of the femora and points of the tarsi lighter. Extremities of the second pair of tibiæ white.

One female from Calcutta.

#### ZALEPTUS THORELLII, n. sp.

♂, ♀. Cephalothorax semicircular. Body straight, the upper-side and the coxæ are finely granular. Ventral segments, some parts of the cephalothorax, and the lamina frontalis smooth. Cephalothorax bears a well-marked depressed triangle, open in front. Lamina frontalis undeveloped; the procursus frontales are large, broad, and strongly toothed. The tubercle is rather low, the upperside somewhat convex; the front and back almost straight, and seen from the side it is as long as high. It is surmounted by a single tooth behind, and four in front. Seen from the front it is broader than high and scarcely narrowed towards its base. The top is deeply channelled. Diameter of the eyes equals the distance between the lower edge of the eyes and the base of the tubercle.

Basal joint of the antenna smooth. Procursus max. internus broad and high, and has an upper process; the lower process is missing, and the lower edge is toothed. Femora of the palps toothed below; patellæ toothed chiefly above, broader towards their edges. Tibiæ three times as long as broad. Tarsi at their lower and inner edges bear the usual row of granules. Femora of the legs and partly their patellæ and tibiæ spinous.

F. I=6 (30), II=10½ (53), III=6 (30), IV=8½ (?) mm. Body 4 mm. Second joint of the antenna 1 mm. in length.

Cephalothorax yellowish, richly spotted with brown. Abdomen brownish with a metallic sheen. Genital plate and coxæ brown; the free ventral segments are greyish-brown, indistinctly spotted with white and black. Femora and the patellæ of the palps brownish, the terminal joints and the antenna yellow. Legs light brown, with the extremities of tibiæ 2 and 4 white. In the females the tarsi of the palps are smooth, the abdomen lighter and non-metallic; the dorsal segments bear a row of indistinct yellow spots.

Male and female from Berbhoom district.

*ZALEPTUS MINUTUS*, n. sp.

♀. Cephalothorax almost triangular. Abdomen flat, and falls gradually behind. Cephalothorax has the ordinary depressed triangle; and there is a longitudinal groove along the margin. Body bears few hairs and has large granules above; the coxæ and genital plate are almost, and the ventral segments completely smooth. Lamina frontalis well developed; the procursus are large, spinous, and separated. The tubercle is low and as high as long; the front edge higher than the back. Seen from the front it is broader than high and narrowed at its base. The top is convex and smooth, with the exception of a single anterior tooth. Diameter of the eyes equal to the distance between their lower edge and the base and less than the distance between them. Basal joint of the antenna granular. Labrum obtuse and pointed, with two short hairs. Proc. max. int. two-branched and low; the upper branch slender, the lower strong and recurved. Both upper and lower edge are sometimes toothed. The palps are broken away. Femora of the legs well toothed and hairy; tibiæ of all the legs bear false articulations. Legs brittle and femora beset with few hairs.

F. I=6, II=11, III=6, IV=9 mm. Body 3 mm. Second joint of the antenna measures  $\frac{3}{4}$  mm.

Abdomen black above; cephalothorax and coxæ dark brown; free ventral segments lighter. Antennæ and legs reddish-brown.

♂. Second dorsal segment bears a low tubercle as in *Scotomenia*; except that in this species it is on the first segment. Palps very long and slender. Tibiæ and patellæ much longer than the femora, which are longer than the tarsi. Patellæ almost as long as the tibiæ, enlarged towards their ends. Tibiæ four times as long as broad. Palps, including the tarsi, smooth; their length is  $3\frac{1}{2}$  mm.

Colour red-brown above, with a broad longitudinal black band running through the abdomen. Palps yellowish-brown.

Colours of the two other specimens are as in the male.

Four specimens from Darjeeling.

*ZALEPTUS HIRSUTUS*, n. sp.

♀. Cephalothorax almost trapezoid. Abdomen oval. Body becomes higher towards the second abdominal segment and falls very gradually behind.

Segments of the scutum marked by distinct transverse grooves. Free segments separated from each other by broad articulations. Depressed triangle of the cephalothorax not distinct. The upper-side, including the base of the tubercle, bears large flat granules. Coxæ almost and the free ventral segments completely smooth. The whole body densely hairy. Lamina frontalis well developed, the procursus small, narrow, and toothed. Tubercle, seen from the side, much higher than long. The front face is the higher and slopes steeply forwards and downwards. The back is the lower and straight. Seen from the front, it is almost as high as broad, and narrowed at its base. Top provided with a low groove and crested with a row of strong teeth. Number of teeth different in each series and not placed in a regular row—but some nearer to, others farther from the middle line. Diameter of the eyes smaller than the distance between them, and one third of the distance between their lower edge and the base of the tubercle.

Basal joint of the antenna smooth or almost smooth above and twice as long as broad. Proc. max. int. low and two-branched—the upper branch pale and slender, the lower curved back and strong, with its lower edge bearing a few large teeth. Femora of the palps bear a few small teeth below. The terminal segments are broken away. Legs very brittle; femora almost smooth and hairy. All the tibiæ have false articulations.

F. I =  $5\frac{1}{2}$ , II =  $10\frac{1}{2}$ , III =  $5\frac{1}{4}$ , IV = 7 mm. Body 4 mm. Second joint of the antenna measures 1 mm.

Body red-brown, the top of the tubercle black. The underside darker. The articulations are yellow; the legs and antennæ brownish.

Four females from Darjeeling.

#### GAGRELLA, *Stol.*, 1869.

I have already considered the difference between *Gagrella* and *Melanopa* on the one side, and *Zaleptus* on the other (*Zaleptus*, anteà, p. 474). I have retained the genera *Hypsibunus*, *Zaleptus*, and *Ceratobunus*, because they have a certain practical value in the synonymy of the group. This, however, is not the case with *Melanopa*. The differences between *Gagrella* and *Melanopa* according to Thorell (10. p. 659) are as follows:—

(1) The first pair of femora are never more than four times as long as the second joint of the antennæ; since, however, in the males of *G. atrata*, *Stol.*, they exceed this proportion, but do not reach it in the females, the character has no value in the definition of the genera.

(2) Femora of the legs in *Melanopa* not only enlarged towards the extremity from the middle, but from the base. This seems only a necessary consequence of the shorter legs, and is certainly of little value.

(3) Fourth pair of coxæ relatively broader towards their extremities than the third. I cannot confirm this character in *Gagrella Hansenii* and *G. varians*, which are *Melanopæ* according to Thorell's definition.

(4) Claw of the palps not dentate. In *Gagrella imperator* the teeth are almost wanting in some specimens but not in others. In *Gagrella Hansenii* they are well developed.

Since all the above characters are variable and insufficient for diagnosis of new species, I prefer to reject the genus *Melanopa* and refer its species to *Gagrella*; and I hope that the following synopsis will be of value, although it has defects, partly due to myself, partly to the vagueness of the original description. Many of the species I do not know, and of most of them I have had but one or two specimens—a very unfortunate fact when they vary, and it becomes necessary to use characters which are partly inconstant.

*Synopsis of Species.*

*a.* Scutum bears one or two spines in a longitudinal row.

*a*<sup>1</sup>. First pair of femora more than four times longer than the second joint of the antenna.

*a*<sup>2</sup>. Tibiæ of palps at least four times as long as broad.

*a*<sup>3</sup>. Frontal eminence provided with a tooth .. *dentata*.

*b*<sup>3</sup>. Frontal eminence smooth.

*a*<sup>4</sup>. Tubercle smooth or almost smooth above.

*a*<sup>5</sup>. Tubercle higher than broad and long . *nobilis*.

*b*<sup>5</sup>. Tubercle more or less low.

*a*<sup>6</sup>. Cephalothorax more or less yellow.

*a*<sup>7</sup>. Abdomen with a longitudinal darker band.

*a*<sup>8</sup>. Cephalothorax yellow, with the exception of an indistinct black band between the tubercle and the front. One brown spine .. *crux*.

*b*<sup>8</sup>. Articulations of the cephalothorax black. Two black spines with yellow base ..... *armillata*.

*b*<sup>7</sup>. Abdomen without longitudinal black band ..... *lepida*.

*b*<sup>6</sup>. Cephalothorax black or brown.

*a*<sup>9</sup>. Legs yellowish-brown. Two spines. The tubercle is low with a few teeth in front. The scutum is granular. Joint 2 of antenna =  $1\frac{1}{4}$  mm. F. I = 10; B. =  $6-6\frac{1}{2}$  mm. *cheetopus*.

*b*<sup>9</sup>. Legs black. Tubercle high and quite smooth. One spine. The scutum is pitted. Joint 2 of antenna =  $1\frac{1}{2}$  mm. F. I =  $8\frac{1}{2}$ ; B. =  $4\frac{3}{4}-7\frac{1}{2}$  mm. .... *sordidata*.

*b*<sup>1</sup>. Tubercle toothed.

*a*<sup>10</sup>. Tubercle has only a few teeth in front. *sordidata*.

*b*<sup>10</sup>. Tubercle is crested with a longitudinal row of teeth.

*a*<sup>11</sup>. Abdomen brown, with two spines and two yellow spots. Second joint of the antenna =  $1\frac{1}{2}$  mm. F. I = 6; B. =  $4\frac{1}{2}-6\frac{1}{4}$  mm. .... *minax*.

*b*<sup>11</sup>. Abdomen brown or black, with one or two spines. The cephalothorax

- is sometimes provided with two white waxy spots. Second joint of antenna = 1 mm. F. I = 6; B. =  $3-4\frac{1}{3}$  mm. .... *erebea*.
- $\delta^2$ . Tibiæ of palps not four times as long as broad.
- $a^{12}$ . Cephalothorax spinous on each side. Tubercle brown. A row of strong teeth around the eyes ..... *spinulosa*.
- $b^{12}$ . Cephalothorax not spinous.
- $a^{13}$ . Legs more or less hairy.
- $a^{14}$ . Body brown with a darker longitudinal band through the scutum; antennæ and palps yellow, and the legs brown. .... *hirta*.
- $b^{14}$ . Colour black. Antennæ and last two joints of the palps yellowish-brown .. *fragilis*.
- $b^{15}$ . Legs either not hairy or with but few small hairs.
- $a^{15}$ . Tubercle completely smooth above.
- $a^{16}$ . Abdomen completely black.
- $a^{17}$ . One or two lighter bands between the tubercle and the front.
- $a^{18}$ . Tubercle yellow; one or two spines. A single lighter band between the tubercle and the front. Second joint of the antenna =  $1\frac{2}{3}$  mm. F. I = 9; B. =  $7\frac{1}{2}$  mm. .... *Fecæ*.
- $b^{18}$ . Tubercle black; two spines. Two yellow bands between the tubercle and the front. Second joint of the antenna =  $1\frac{2}{3}$  mm. F. I. =  $6\frac{3}{4}$ ; B. =  $7\frac{1}{2}$  mm. .... *nocticolor*.
- $b^{17}$ . No lighter band between the tubercle and the front ..... *atrata*.
- $b^{16}$ . Abdomen not completely black.
- $a^{19}$ . Abdomen black with a yellowish longitudinal band. Tubercle high and in front granular below. Ventral segments bear transverse rows of granules ..... *Maindrom*.
- $b^{19}$ . Scutum bears a yellowish spot on each side before the spine ..... [*humeralis*].
- $c^{19}$ . Abdomen black with yellow sides.
- $a^{20}$ . Whole body granular. A yellow band runs from the tubercle



- to the front and is continued abdominally as two marginal bands..... *signata*.
- $\delta^{20}$ . Body only partly granular. Scutum has four yellow longitudinal bands ..... *quadrivittata*.
- $\epsilon^{16}$ . Body blackish with a metallic or phosphoric shade. Joint 2 of the antenna =  $1\frac{1}{2}$  mm. F. I =  $10\frac{1}{2}$ ; B. =  $4\frac{1}{4}$  mm. .... *ænescens*.
- $\alpha^{16}$ . Body reddish or yellowish-brown.
- $\alpha^{21}$ . Tubercle, seen from the side, almost as high as broad. The abdomen reddish-brown with a longitudinal darker band. Joint 2 of the antenna =  $1\frac{1}{2}$  mm. F. I =  $10\frac{1}{2}$ ; B. =  $4\frac{1}{2}$ –5 mm. .... *laticlavia*.
- $\delta^{21}$ . Tubercle, seen from the front, almost twice as broad as high.
- $\alpha^{22}$ . Tubercle and palps completely smooth ..... *rufescens*.
- $\delta^{22}$ . Tubercle armed in front, under the eyes, with a row of strong teeth..... *Stoliczka*.
- $\epsilon^{16}$ . Body granular, with large and low granules, which are placed distant from each other. Colour greyish, with an abdominal longitudinal darker band; underside white, with darker spots. Tubercle smooth; palps toothed ..... *mirabilis*.
- $f^{16}$ . Brown with black spots ..... *imperator*, var.
- $\delta^{16}$ . Tubercle more or less toothed above. [*unispinosa*, ♀.
- $\alpha^{23}$ . Abdomen more or less black.
- $\alpha^{24}$ . Abdomen completely black.
- $\alpha^{25}$ . No lighter band between the tubercle and the front ..... *atrata*.
- $\delta^{25}$ . A lighter band between the tubercle and the front..... *Fec*.
- $\delta^{24}$ . Abdomen not completely black.
- $\alpha^{26}$ . Body black with exception of the brown antennæ and the terminal joints of the palps. Scutum on each side of the spine bears six yellow spots of a waxy nature ..... *flavimaculata*.

- b*<sup>26</sup>. Body black with exception of two yellow spots at the hindmost part of the abdomen. Tubercle with a row of granules. *binotata*.
- c*<sup>26</sup>. Cephalothorax with a white triangle; scutum with two large white spots. Second joint of antenna 2 mm. long. F. I =  $13\frac{1}{2}$ ; B. = 8 mm. .... *histrionica*.
- d*<sup>26</sup>. Body black, with the exception of the usual triangle and a longitudinal yellow spot on each side of the spine ..... [var. *fusca*. *triangularis*,
- e*<sup>26</sup>. Scutum black, with a large waxy white spot in the front and a smaller one behind. One spine. The ventral segments are yellow with black spots. The coxæ are black ..... *ceylonensis*.
- b*<sup>23</sup>. Abdomen yellow or brown.
- a*<sup>27</sup>. Body yellowish. Cephalothorax with a yellow spot in front. The spine, a spot at its base, and marginal spots black. Tubercle rather high and armed with a row of teeth. Second joint of the antenna  $1\frac{1}{2}$  mm. long. F. I = 14; B. = 5 mm. .... *cervina*.
- b*<sup>27</sup>. Body bears one short spine. Tibiæ twice as long as broad. F. I = 8; F. II = 14; B. =  $4\frac{1}{2}$  mm. Colour yellow or yellowish-brown, and there is sometimes a more or less marked longitudinal darker band. Cephalothorax bears a yellow triangular spot, encompassing the tubercle. Palps, antennæ, and legs yellowish-brown or yellow ..... *triangularis*.
- c*<sup>27</sup>. Body armed with two long spines. Tubercle provided with teeth above. Colour reddish-brown ..... *imperator*.
- a*<sup>23</sup>. Tubercle provided with small teeth above. .... *imperator*,  
forma typica.

- b*<sup>28</sup>. Tubercle provided with larger teeth above and under the eyes. [var. *dentata*.  
*imperator*,  
*a*<sup>29</sup>. Scutum reddish-brown. One black spine ..... [unispinosa ♂.  
*imperator*, var.  
*b*<sup>1</sup>. First pair of femora not more than four times as long as the second joint of the antennæ.  
*a*<sup>30</sup>. Tubercle provided with strong teeth around the eyes ..... *plebeia*.  
*b*<sup>29</sup>. Tubercle smooth or granulated.  
*a*<sup>30</sup>. Body granular above and below ..... *tristis*.  
*b*<sup>30</sup>. Free ventral segments smooth.  
*a*<sup>31</sup>. Body much raised towards the single spine ..... *Hansenii*.  
*b*<sup>31</sup>. Body not more raised than usual.  
*a*<sup>32</sup>. ♀. Body completely black. Spine smooth. ♂. Terminal joints of the palps yellow ..... *atrata*.  
*b*<sup>32</sup>. ♀. Blackish-brown. Spine granular.  
 ♂. Palps completely yellow ..... *varians*.  
*b*. Scutum with two spines in a transverse row.  
 Tubercle smooth ..... *bispinosa*.

*GAGRELLA DENTATA*, n. sp.

♀. Cephalothorax almost triangular. Scutum bears two very long spines: the first directed upwards and forwards, the second almost perpendicular. Body raised towards the first spine, and sloping behind the second. Penultimate segment of the cephalothorax narrow, the last is not so broad as the articulations between the cephalothorax and the scutum. Frontal eminence well developed and armed with a short distinct thorn, directed upwards and forwards. A distinct lamina frontalis is very well developed, triangular and spinous. Granulation of the body, with the exception of the well-granuled coxæ, so very little marked that it becomes smooth. Tubercle, seen from the side, rather high and convex, as high as long; seen from the front it is much broader than high. In front there is a thorn on each side of the groove, as long as the diameter of the eyes. There are two granules under the eyes, and the diameter of the eyes is much less than the distance between them, and greater than the distance between their lower edge and the base of the tubercle. Basal joint of the antenna almost smooth.

Procursus maxillaris internus long, slender, pointed, and pale; the upper branch very long, the lower very short; its lower

edge granular. Palps hairy but without teeth, with the exception of some very small ones on the patellæ and tibiæ. Patellæ long and enlarged towards their extremities. Inwardly there is a long slender apophysis, as long as the patellæ are broad. Tibiæ five times as long as broad. The legs are very long and slender; the femora spinous.

F. I=12 (53), II=24 (120), III=10 (45), IV=6 (70) mm. Body 5-7 mm. Second joint of the antenna  $1\frac{1}{4}$  mm. long.

Colour white with some few dark spots. The procursus frontales, tubercle, and articulations are yellowish-brown. A longitudinal broad band from the first spine to the end of the abdomen is indistinctly brown. The top of the spines is black, the coxæ and genital plate brown, the ventral segments yellow with white spots on the side, the point of coxa 4 with a yellow spot in front. The antennæ and palps are yellow, the legs brown.

One full-grown female from "Large Nicobar."

Another specimen from Little Nicobar has no patellar apophysis. The procursus frontales are smaller. The colour is bluish-white, the longitudinal band yellow. The segments of the scutum are marked by a row of depressed dark spots.

The last specimen, also from Little Nicobar, is a little different from the other two. Instead of the frontal spine there is a short apophysis, armed with three short pointed teeth. Beneath this apophysis there is a short pointed tooth. The scutum is finely granular. Apophysis of the patella short. The femora of the palps bear an inner row of granules. Tubercle black.

This beautiful and odd species was taken by the Danish 'Galathea' Expedition.

*GAGRELLA NOBILIS*, n. sp.

♀ (?). Cephalothorax almost square; the scutum bears one thorn; the area between the ocular tubercle and the spine is almost plane. The upperside is densely and finely granular with the exception of the tubercle, spine, and free dorsal segment. The free ventral segments are smooth; coxæ partly smooth, partly beset with large distinct granules. The lamina frontalis is undeveloped; the procursus are small, narrow, well separated, and armed with few teeth. The tubercle is very characteristic; seen from the side it is somewhat higher than long, its upperside is almost flat; the front side sloping and higher than the back.

Seen from the front, the tubercle narrows beneath the eye and is as high as broad. The crest is grooved and provided with five long hairs on each side. Diameter of the eyes both less than the distance between them, and than the space from their lower edge to the base of the tubercle.

Basal joint of the antenna once and a half as long as broad, and smooth. Procursus max. internus two-branched and pale; its lower edge bears dark teeth. The femora of the palps are as long as the tibiæ+patellæ and the tarsi. Beneath and at the base of the patellæ they are toothed. Patellæ hairy and toothed. Tibiæ four times as long as broad. Tarsi with few teeth below, and the femora of the legs hairy and with the usual small teeth.

F. I=9 (46), II=17, III=8 (43), IV=12 mm. Body 4 mm. Second joint of antenna  $1\frac{1}{2}$  mm. long.

On both sides of the tubercle the body is white; the hindmost part of the cephalothorax and the abdomen is yellowish and brown, the three colours merging into each other. A dark depressed spot on each side of the tubercle. Tubercle black, and connected with the front by a broadening black band. Five or six light yellow spots are placed in a row on each side of the scutum near the middle. Last two free dorsal segments black, with a longitudinal white spot on each side. Free ventral segments yellowish-white with indistinct black spots. First pair of coxæ white, the second black, the third and fourth white at the base, and black spotted with yellow at their extremities. The trochanters and the femora of the palps are black; their terminal joints, the antennæ, and the mouth-organs are yellow, the legs brownish, and the points of the second and fourth tibiæ white. The spine is black.

One female (?) from Silouri.

*GAGRELLA CRUX*, n. sp.

♀. Cephalothorax almost triangular. Tubercle placed near the articulation, since the next last segment of the cephalothorax is small. The last segment well developed. The five segments of the scutum marked by darker transverse striæ. The body granular above, with the exception of some parts of the cephalothorax, the spine, and the tubercle; the coxæ are almost smooth, and the free ventral segments completely so. The cephalothorax

presents the usual depressed triangle. On each side along the margin there is a depressed groove, and near the tubercle a black depressed spot. Procursus frontales more or less separated and spinous. Tubercle low, convex, and longer than high, and seen from the side it is on each side beset with two small teeth. In front it is broader than high. There is the usual groove above. The diameter of the eyes is less than the distance between them, and larger than the space between their lower edge and the base of the tubercle.

Basal joints of the antennæ granular. Procursus max. int. two-branched and pale, the upper branch short or absent; the lower edge granular. The palps are slender and hairy, but without teeth, with the exception of the patellæ, which have a few at the side. Femora as long as the tarsi and shorter than the sum of patellæ and tibiæ. Patellæ have an inner apophysis, which varies very much in the different specimens, even in the two palps. It may be slender or stout, pointed or obtuse, well developed or almost absent. Tibiæ five times as long as broad.

Femora of the legs spinous, and the second pair of tibiæ with false articulations.

F. I =  $7\frac{1}{2}$  ( $32\frac{1}{2}$ ), II =  $12\frac{1}{2}$  (64), III =  $6\frac{1}{2}$  ( $30\frac{1}{2}$ ), IV =  $9\frac{1}{2}$  (45). Body 3 mm. Second joint of the antenna  $\frac{3}{4}$  mm. long.

Cephalothorax yellow, with the exception of some depressed spots and a more or less narrow indistinct band between the tubercle and the front. Tubercle brown, in front yellow. The segments between the tubercle and the black front margin of the scutum are black, the articulations lighter, and this black transverse band is continued along the margins of the scutum, through which there runs a longitudinal broad black band. Space between the central and marginal black bands yellow, but subdivided by four indistinct narrow transverse black bands denoting the segments. The first two free dorsal segments bear a central and two marginal black spots and two that are white. Genital plate and free ventral segments yellow; coxæ white with a brown base. Antennæ yellow, the second joint with transverse black spots. Palps and legs yellow with the exception of the black trochanters.

This species is similar to *G. lepida*, Thor., but differs in its colour and shorter legs.

Three females from Punkabari.

*GAGRELLA ARMILLATA*, Thor.

Thorell, (10) p. 629.

*G. LEPIDA*, Thor.

Thorell, (10) p. 626.

The tarsus of the palps of the males is smooth.

*G. CHÆTOPUS*, Thor.

Thorell, (10) p. 631.

*G. SORDIDATA*, Thor.

Thorell, (10) p. 634.

The tarsus of the palps of the male is smooth.

*G. MINAX*, Thor.

Thorell, (10) p. 638.

The tarsus of the palps of the male is smooth.

*G. EREBEA*, Thor.

Thorell, (10) p. 636.

♂. The femora of the palps alone bear small teeth. The patellæ have no inner apophysis. The tarsi bear the usual inner row of granules, which are small and placed somewhat apart. Colour brown, with indistinct black spots above. Cephalothorax yellowish-brown. The articulations are yellow, the coxæ brown, and the ventral segments yellowish. Both sides of the cephalothorax in front and the coxæ partly covered with a white waxy material. Antennæ and palps yellowish-brown; the legs yellow.

As the male described here is in all other respects similar to *G. erebea*, Thor., and as it is one of Fea's original specimens, I conclude that the differences are only such as occur between males and females.

*G. SPINULOSA*, Thor.

Thorell, (10) p. 657.

The tarsi of the palps of the males are smooth.

*G. HIRTA*, n. sp.

♀. Cephalothorax almost square. Body somewhat raised towards the single spine, falling gradually behind. It is not very densely granular above, and the coxæ, the free dorsal segments, the spine, and the genital plate are less so. Lamina, procursus

frontales, tubercle, free ventral segments, and spots on cephalothorax smooth. Cephalothorax with the usual depressed triangle. The whole body is densely hairy, the "hairs" curved and yellow. Frontal eminence well marked. Procursus frontales well separated, small, and spinous at their points. The tubercle, seen from the side, is higher than long and convex, the front higher than the back. The top is convex and surmounted by a row of yellow hairs on each side of the groove. Seen from the front it is as broad as high, and narrows towards its base. The diameter of the eyes is as great as the distance between them, and a little less than the distance between their lower edge and the base of the tubercle.

Basal joint of antenna smooth, and almost twice as long as broad. Procursus maxillaris internus two-branched, the upper branch small and pale; the lower larger, with a granular lower edge.

Femora of the palps as long as the patellæ and tibiæ, but shorter than the tarsi; toothed below and above at the base of the patellæ. The patellæ are enlarged towards their extremities and densely toothed, chiefly on the inner side. Tibiæ twice and a half as long as broad and granular.

Femora of the legs strongly hairy.

F. I =  $7\frac{1}{2}$  (35), II = 13 (70), III =  $7\frac{1}{2}$  (35), IV =  $10\frac{1}{2}$  (50) mm. Body  $5\frac{1}{2}$  mm. The second joint of the antenna is  $1\frac{1}{2}$  mm. long.

Body light brown, with a longitudinal broad darker band through the abdomen. Cephalothorax has darker spots. Base of the tubercle brown; eyes and parts around them black. A yellow band, narrow in the front and broad behind, runs between the eyes. Coxæ and genital plate brown; the free segments are lighter. Antennæ yellow. Palps and legs brown; the latter are lighter towards their extremities.

One female from Punkabari.

*GAGRELLA FRAGILIS*, n. sp.

♀, ♂. Cephalothorax almost square. Abdomen raised towards the single spine. Segments separated from each other by broad articulations in the pregnant females, which also have the lateral parts of the ventral segments well developed. Cephalothorax presents the usual depressed triangle, open in the front. The upperside is granular; the coxæ and genital plate less densely granular. The articulations, the spine, the lamina frontalis, and



the last two dorsal segments are almost, and the free ventral segments are completely, smooth. Frontal eminence indistinct, and only bears a few large granules. Scutum hairy behind the spine. Lamina frontalis indistinct; procursus small, partly separated and toothed.

Tubercle, seen from the side, is as long as high; convex above and behind. The front face is the higher. It is broader than high, as seen from the front, and somewhat narrower at the base. The top is deeply grooved, hairy, but hardly ever granular. The diameter of the eyes is as great as the distance between them, and greater than that between their lower edge and the base of the tubercle.

Basal joint of the antennæ smooth. Procursus max. internus two-branched. Femora of the palps both shorter than the patellæ+tibiæ and than the tarsi, and toothed below. Patellæ enlarged towards their extremities, and toothed. Tibiæ, which are almost smooth, are twice and a half as long as broad. The tarsi are hairy, and in the males armed with the usual row of conical teeth at the inner lower edge.

Femora of the legs strongly hairy; the legs very brittle.

F. I =  $6\frac{1}{2}$  (30), II =  $10\frac{1}{2}$  (?), III = 6, IV =  $8\frac{1}{2}$  mm. Body 5-7 mm. The second joint of the antenna is  $1\frac{1}{2}$  mm. long.

Colour blackish-brown, the underside and the articulations lighter. Antennæ and last two joints of the palps yellowish-brown; legs brown, but lighter towards their extremities.

A great number of specimens from Darjeeling.

Var. *bispinosa* is similar to the described species, but it has only two spines.

One specimen from Darjeeling.

*GAGRELLA FEE*, *Thor.*

Thorell, (10) p. 648.

The tarsi of the palps (♂) bear the usual row of teeth.

*G. NOCTICOLOR*, *Thor.*

Thorell, (10) p. 651.

The tarsi of the palps (♂) bear the usual row of teeth.

*G. ATRATA*, *Stol.*

Stoliczka, (5) 1869, p. 213.

♀. Cephalothorax semilunar. Scutum raised towards the single spine. Free segments, as usual in the pregnant females,

well separated from each other. This fact is mostly evident from above, on account of the granulation. Last segment of the cephalothorax separated both from the scutum and from the rest of the cephalothorax by articulations, as broad as the segment itself. Articulations between the free dorsal segments broader than the segments. Space between the scutum and the free ventral segments very broad, in front as broad as the scutum, which seems to be disposed as a cap on the top of the abdomen. The lateral parts of the free ventral segments well developed, the ventral segments being transversely grooved near their hinder margin. In the young females the shape of the body is as in the males. Cephalothorax presents the usual depressed triangle. Scutum, cephalothorax, first free dorsal segments, the coxæ, the genital plate, and the lateral parts of the first free ventral segments distinctly granular. Middle part of the ventral segments, the last two dorsal, the spine, and the tubercle smooth. Procursus frontales partly united, stout and toothed.

Tubercle very low, convex, and longer than it is high. The top is smooth or on both sides of the groove crested with a few small teeth. In front under the eyes a row of five teeth.

The basal joints of the antennæ bear black granules above. Procursus max. internus two-branched, the upper branch is slender, the lower edge toothed. Femora of the palps bear inwardly a row of short conical teeth, and outwardly a row more irregularly placed. In the middle they are smooth. Both tibiæ and patellæ are toothed, and the tibiæ are twice and a half as long as broad. Tarsi hairy, and sometimes with a few teeth below.

Femora shorter than tarsi and longer than patellæ + tibiæ. Femora of the legs granular.

F. I = 5 (23), II = 8 (44), III = 5 (23), IV = 7 (33) mm. Body 5-7 mm. Second joint of the antenna  $1\frac{1}{4}$  mm. long.

Body black. Free ventral segments lighter. Space between the eyes in some specimens light brown, and the cephalothorax beset with lighter spots. Articulations, palps, and antennæ yellowish-brown; legs blackish-brown; the base of the femora lighter.

♂. Femora of the tarsi toothed below, with no difference between the outer and inner row. Tibiæ smooth. Tarsi bear a long row of teeth (30-50), which extends from the base to the

last third part. Legs of different lengths, but generally longer than in the females.

F. I = 5-7 (32), II = 9-10½ (50), III = 5-7 (32), IV = 8-9½ (40) mm. Body 5½ mm.

Space between the eyes and between the tubercle and the front yellowish-brown. Antennæ yellow; the second joint spotted with transverse black bands. Terminal joints of the palps yellow. The femora of the legs show a distinct light-brown ring. Legs usually black, but in two specimens brown. Articulations between the coxæ and the trochanter white.

A great number from Calcutta.

This species is without doubt identical with *G. atrata*, Stol. There is only a slight difference in the granulation; while Stoliczka's species is also granular below.

*G. atrata* is very similar to *G. Fœæ* and *G. nocticolor*, Thor., but especially to *G. varians*, n. sp. It is almost impossible to distinguish the females from each other.

*GAGRELLA MAINDRONI*, Sim.

E. Simon, (16) 1897, p. 296.

*G. SIGNATA*, Stoliczka.

Stoliczka, (5) 1869, p. 214.

*G. QUADRIVITTATA*, Sim.

E. Simon, (9) 1887, p. 115.

*G. ÆNESCENS*, Thor.

Thorell, (10) 1889, p. 643.

With regard to the difference between the palps of the males and the females, consult Thorell. The tarsi of the males bear a row of granules, which begin near the base and are continued towards the extremity. The teeth in the proximal half are placed relatively close to each other, while in the distal part they are distant.

Femur II=21 mm. Thorell has only 11. It is probably a printer's error.

*G. LATIOLAVIA*, Thor.

Thorell, (10) 1889, p. 641.

*G. RUFESCENS*, Thor.

Thorell, (10) 1889, p. 645.

*GAGRELLA STOLICZKE*, n. sp.

♀. Cephalothorax somewhat triangular. Body somewhat raised towards the single spine, with granules above flat, not very densely placed. Spine granular. Free dorsal segments, the coxæ, and genital plate bear a few small granules. Free ventral segments, lamina frontalis, and tubercle smooth. Cephalothorax presents the usual depressions. Lamina frontalis well developed; procursus frontales long, enlarged towards their edges, and toothed.

The tubercle, seen from the side, is low and convex. The front is in breadth once and a half its height, and is scarcely narrower towards its base. The top is grooved, hairy, and smooth; but in the front under the eyes there is a row of well-developed teeth, curved upwards. Diameter of the eyes smaller than the distance between them, but larger than the distance between their lower edge and the base of the tubercle.

Basal joint of the antennæ about twice as long as broad and granular above. Procursus max. internus two-branched. Femora of the palps longer than the patellæ and tibiæ, but shorter than the tarsi, toothed below and above at the base of the patellæ. Tibiæ and patellæ spinous. Tibiæ twice and a half as long as broad. Femora of the legs bear small teeth.

F. I=8, II=14 (c. 80), III=7½, IV=11½. The second joint of the antenna is 1½ mm. long. Body 6 mm.

Upperside brown; scutum with transverse black bands to mark the segments. Colour lighter in front and behind. Tubercle yellow between the eyes. Underside lighter. Antennæ and palps yellowish-brown. Trochanters, spine, and base of the femora black. Legs light brown, with darker patellæ. Articulations between trochanters and coxæ white.

One female from Tenasserim.

This species is very similar to *G. rufescens*, Thor.

*GAGRELLA MIRABILIS*, n. sp.

Cephalothorax almost triangular. Body raised towards the single spine, which presents a very singular appearance. It is short and thick, and its point is bent downwards along its lower part. I do not at all think that this shape is natural, but that it has been caused by violence while undergoing ecdysis. The body bears relatively few, large, and low granules. The spine is also granular. Free ventral segments smooth. Lamina

frontalis small; the procursus frontales distinct, pale, and toothless.

Tubercle rather long and smooth. The front edge is seen to decline; the back is perpendicular. Viewed from the side, it is almost as high as long. Diameter of the eyes almost as large as the distance between them, and a little larger than the distance between their lower edge and the base of the tubercle. Basal joint of the antenna smooth. Procursus max. internus two-branched and smooth, but with the branches almost parallel and bent downwards and forwards. Femora of palps bear long pointed teeth; patellæ and tibiæ bear smaller. Tibiæ three times as long as broad. Femora of the legs spinous.

F. I=10 (50), II=20 (86), III=10 (42), IV=14 (65). The second joint of the antenna is  $1\frac{1}{2}$  mm. long. Body 5 mm.

Colour greyish, with an indistinct darker longitudinal band. Cephalothorax with a few dark depressed spots. Coxæ and ventral segments white with darker spots, especially distinct at the coxæ. Extremities of the coxæ and marginal teeth black. Antennæ yellow, palps and legs yellowish-brown.

One mutilated specimen from Mooleyit (500-600 m.).

This animal was mounted as *G. laticlavata*, Thor., in the Zoological Museum of Copenhagen; but as it differs much from the description of *G. laticlavata*, and as Thorell's specimens of *G. laticlavata* are from Thagatá, Jüvá, I think there has been a mistake, and I accordingly establish a new species.

*GAGRELLA FLAVIMACULATA*, n. sp.

♂. Cephalothorax broad and semicircular. Segments of the scutum (which bears a spine) marked by distinct transverse grooves. Along the margin of the first half part of the abdomen there is a longitudinal groove. Granulation of the upper-side fine and dense; coxæ beset with fewer and longer granules. Free ventral segments smooth. Procursus frontales small, pointed, and smooth.

Tubercle, seen from the side, almost straight above, and longer than high, beset with a few granules. Seen from the front, it is as high as broad, and narrower below. Diameter of the eyes larger than the distance between their lower edge and the base of the tubercle, but smaller than the distance between them. Basal joint of the antennæ smooth. Femora and patellæ of the palps toothed, the tibiæ smooth. Tibiæ three and a half

times as long as broad. Tarsi ( $\sigma$ ) bear two rows of teeth: the inner proximal row extends to near the middle, and consists of twelve small flat teeth, placed near to each other with the exception of the last; the outer distal row begins before the middle, but does not reach the extremity, and its few stout teeth are placed very far apart.

Femora of the legs bear small teeth.

F. I= $14\frac{1}{2}$ , II=20 (c. 100), III= $13\frac{1}{2}$ , IV=18. Second joint of the antenna  $1\frac{1}{4}$  mm. in length. Body  $5\frac{1}{2}$  mm.

Colour black, with the exception of the second joint of the antenna and the terminal joints of the palps, which are brown. On each side of the abdomen are six yellow spots of a waxy material, and the coxæ are covered with a similar mass. The tubercle is brown.

One mutilated male without locality.

*GAGRELLA BINOTATA*, *Sim.*

Simon, (9) 1887, p. 115.

*G. HISTRIONICA*, *Thor.*

Thorell, (10) 1889, p. 652.

*G. CEYLONENSIS*, *Karsch.*

Karsch, (13) 1892, p. 308.

*G. CERVINA*, *Sim.*

Simon, (9) 1887, p. 115; Thorell, (10) 1889, p. 655.

*G. TRIANGULARIS*, n. sp.

♀, ♂. Cephalothorax square or triangular. Body higher towards the single spine and sloping gradually behind, its upper surface densely granular. Spine, coxæ, genital plate, and some parts of the cephalothorax less granular; the free ventral segments, lamina, and procursus frontales quite smooth. Depressions of cephalothorax little marked. Lamina frontalis well developed, with slender and pointed procursus.

Ocular tubercle convex and almost as high as long; when viewed from the side, its front face higher and more sloping. The tubercle is, on each side of the groove, surmounted by larger and smaller teeth, which are continued as a row of granules under the eyes. Seen from the front, it is almost as

high as broad, and narrower towards its base. Diameter of the eyes as large as the distance between them, and much larger than the distance between their lower edge and the base of the tubercle. Basal joint of the antennæ smooth. "Fingers" in some specimens irregularly toothed; the labrum (epistoma) in some club-like. The procursus max. internus two-branched and toothed.

Femora of the palps strongly spinous below. Teeth arranged in two rows—an inner of flat and stout, an outer of more or less pointed spines, but not in a regular row. Patellæ spinous, and with a small inner apophysis. Tibiæ granular and twice and a half as long as broad. Tarsi of the females hairy and smooth; and in one specimen with indistinct tarsal teeth, placed in two rows. Tarsi of the males, with regard to their dentation, similar to *G. flavimaculata*. The lower side has two rows of teeth—a proximal row beginning near the base and extending almost to the middle near the inner side; it consists of c. 20 small flat teeth, which are placed near to each other with the exception of the last. The distal row along the outer margin begins near the middle and extends to the extremity; it consists of c. 10 small pointed teeth, placed far apart.

Legs long, stiff, and with small teeth.

F. I =  $8\frac{1}{2}$  (35), II = 13 (62), III = 8 (33), IV =  $10\frac{1}{2}$  (45) mm. Body  $4\frac{1}{2}$  mm. Second joint of the antenna 1 mm. long.

Colour red-brown, with larger or smaller irregular yellow spots; and sometimes there runs through the abdomen a darker longitudinal band. Cephalothorax bears a yellow triangular spot, turned forwards and encompassing the tubercle. This triangle has two darker spots on each side and a pointed narrow one in front. Ventral segments and coxæ lighter. Spine blackish-brown. Antennæ and the palps yellow. Legs yellowish-brown.

#### Var. FUSCA.

Body black, with the usual yellow triangle and a long yellow spot on each side of the spine. Tubercle black, but yellow between the eyes. Last segments of the cephalothorax brown with yellow spots. Coxæ brown. Ventral segments, with antennæ, palps, and legs, yellowish-brown.

The missionary Mr. Löventhal has captured many specimens (only two of the variety) at Vellore, near Madras.

*GAGRELLA IMPERATOR*, n. sp.

♀. Cephalothorax somewhat semilunar. Scutum bears two spines, placed on the first and on the second segment; the foremost shorter and directed forwards and upwards; the hindmost more perpendicular. The body is higher towards the spine, and behind it slopes gradually. It is very dilated in the gravid females, and the articulations are well developed. The body and, especially, the top of the scutum are finely granular above. Cephalothorax less densely granular; the coxæ and the spine with fewer and larger granules. Ventral segments and articulations smooth. Cephalothorax presents the usual depressions. Frontal eminence well marked; lamina frontalis distinct and the procursus rather long, separated at their outer ends, and spinous.

Tubercle low and, seen from the side, as high as long. The front area is higher than the back and not perpendicular. Seen from the front, it is broader than high and narrowed at its base. Five small teeth on each side of the groove. Diameter of the eyes larger than the distance between their lower edge and the base of the tubercle, but less than their distance apart. Basal joint of the antennæ almost smooth above. Procursus max. internus two-branched and yellow, the lower edge with a few granules.

Femora of the palps shorter than the tarsi and longer than the patellæ + tibię. Femora toothed below. Tibię twice and a half as long as broad. Both tibię and patellæ are granular, chiefly on their inner areas.

Femora of the legs, as usual, granular. Tibię 2 have false articulations.

F. I=8 (35), II=17 (c. 80), III=8½ (35), IV=12 (45). Second joint of the antenna 1¼ mm. long. Body 8½ mm.

Colour a little different in the three specimens—one completely yellow, and soft as if in the condition for ecdysis; the two others light brown, but more or less spotted with yellow. Spines somewhat darker. Coxæ brown.

Three specimens (♀) from the Andamans.

## Var. DENTATA.

Granules larger. Tubercle surmounted by large teeth and provided with a row of granules under the eyes. Basal joint of the antennæ granular.

One female from the Andamans.



## Var. UNISPINOSA.

♀. Scutum has only one long spine; in one specimen there is a little spine in front of the long one. Tubercle smooth. Legs long.

F. I=12 (60), II=26, III=11, IV=16.

Colour brown with black spots, or with the last segments of the cephalothorax darker. Antennæ yellow. Palpi yellowish-brown. Legs brown.

♂. Tubercle bears a few teeth above; tarsi bear an inner row of about 20 teeth, placed rather far apart. Cephalothorax black or blackish-brown; the scutum brown with a black spine.

Three free dorsal segments black in the front, yellow-brown behind. Underside blackish.

The Danish 'Galathea' Expedition has taken three specimens from the "Little" and three from the "Large" Nicobar.

Though the var. *unispinosa* is somewhat different from the main type, I prefer at present to place them in the same species. The characters which distinguish them seem to be fluctuating, as, for instance, the length of the legs, the armature of the scutum, and the tubercle. When we have acquired richer material from the different islands of the two groups, it will be possible to estimate better the value of these differences.

## GAGRELLA PLEBEIA (Thor.).

Thorell, (10) 1889, p. 659. (*Melanopa plebeia*.)

Lateral parts of the ventral segments partly granular. Tarsi of the males smooth. The two specimens, which are mounted as Thorell's original specimens in the Museum at Copenhagen, are very different with regard to the femora of the legs. The femora in one resemble those of an ordinary *Gagrella*, but in the other they are very odd.

The femora of especially the fourth pair of legs are very thick and gradually thicken from the base to the extremity, the outer and under sides are strongly curved inwards; and it is probably such femora which suggested to Thorell the genus *Melanopa*.

## GAGRELLA TRISTIS (Thor.).

Thorell (10) 1889, p. 662. (*Melanopa tristis*.)

Palps of the males with the usual tarsal row of teeth.

*GAGRELLA HANSENII*, n. sp.

♂. Cephalothorax triangular. Body much raised towards the single spine, the point of which is curved backwards. Free ventral segments transversely grooved, whereby the back margin becomes more marked. Lateral parts well developed, and their hindmost (non-granular) parts merge into the corresponding part of the central one.

Body beset with large, dense granules. The foremost part of the lateral pieces of the ventral segments bears smaller granules, and the genital plate bears very few and large. Cephalothorax presents a well-marked depressed triangle. Lamina frontalis indistinct; procursus stout, partly united, and toothed.

Tubercle low, seen from the side it is somewhat longer than high. The top is deeply grooved, but smooth. A row of granules under the eye. The diameter of the eyes is as large as the distance between them, and larger than the distance between their lower edge and the base of the tubercle.

Basal joint of the antennæ smooth above. Proc. max. internus two-branched and low, the upper branch pointed and slender, the lower stout and obtuse. The lower edge granular. Femora and patellæ of the palps toothed. Tibiæ almost smooth, and twice and a half as long as broad. The tarsi bear a long row of teeth, which are stout, obtuse, and pressed downwards. Femora of the legs spinous; false articulations of the second pair of the tibiæ very distinct.

F. I = 4 (22), II = 7 (35), III = 4 (22), IV =  $6\frac{1}{2}$  mm. Body 5 mm. Second joint of the antenna 1 mm. long.

Body black. Antennæ, the two terminal joints of the palps, and the mouth-organs yellowish-brown. Legs black, with the exception of a brown ring near the base of the femora.

One male from Todaspoor.

*GAGRELLA VARIANS*, n. sp.

♀. Cephalothorax almost semilunar. Body a little raised towards the single short spine, finely and densely granular, with the exception of the top of the spine, the free ventral segments, and the articulations. Procursus frontales united, smooth, and toothed.

Tubercle low, convex, and longer than high; seen from the front it is broader than high. The top on each side of the low groove is provided with small teeth; others are placed under

the eyes. Diameter of the eyes as large as the distance between them.

Basal joint of the antennæ granular above. Procursus max. internus two-branched. Femora of the palps toothed below and partly above. Patellæ short and toothed. Tibiæ twice as long as broad, and with small teeth below. Femora of the legs spinous; tibiæ of the second pair with very distinct false articulations. Second pair of legs very slender.

F. I = 4-5 (c. 22), II =  $6\frac{1}{2}$ -8 (35), III 4-5 (22), IV = 6-7 (28) mm. Body 6 mm. Second joint of the antenna 1 mm. long.

Colour black, space between the eyes lighter. Antennæ and the palps yellowish-brown, spotted with black. Femora and the tarsi of the legs light brown, tibiæ and patellæ black.

Two females from Berbhoom District.

The described female is very similar to *G. atrata*. Its common aspect and colour are a little different; the femora are more slender.

#### Var. DENTATA.

♀. Upperside and coxæ beset with large dense granules. Spine almost granular to its point. Tubercle on each side of the deep groove crested with a row of rather long teeth.

Colour blackish-brown, with the cephalothorax and especially the space between the eyes lighter. Ventral segments and the coxæ light brown. Antennæ and the terminal joints of the palps yellow. Legs more or less brown, with darker patellæ and tibiæ.

One female from Berbhoom.

♂. Body beset with dense and large granules. Tubercle surmounted by a row of strong granules, continued under the eyes. Tibiæ of the palps three and a half times as long as broad. Tarsi with the usual row of strong conical teeth.

Body 5 mm.

Colour brown, with black spots; most distinct are the transverse spots of the scutum which mark the segments. Spine black. The single specimen has a longitudinal darker band through the scutum. Space between the eyes yellowish. Ventral segments lighter. Antennæ and the palps yellow. Legs brown.

Two specimens from Berbhoom.

I have great doubt as to the limitation of this species, since the females are in most characters similar to *G. atrata*, Stol.

On the other hand, it seems unnatural for me to refer it to another species than that represented by the male; and as this is very well characterized, I have found it most correct to grant the species the afore-named limitation.

*GAGRELLA BISPINOSA*, *Karsch*.

Karsch, (13) 1892, p. 309.

*G. MONACANTHA* (*Herbst*).

Herbst, (1) 1798, p. 19.

I think it impossible to identify this species from the description.

*SCOTOMENIA*, *Thor.*, 1889.

*SCOTOMENIA CETRATA*, *Thor.*

Thorell, (10) 1889, p. 665.

With regard to the other genera described from India, I refer to the following papers:—

Thorell, 10.

Simon, 8.

C. L. Koch, 2.

On full consideration it seems natural for me to refer the genera *Syleus*, *Thor.*, *Systemocentrus*, *Sim.*, and *Oncobunus*, *Thor.*, to the same genus.

Besides the species herein described, I have had some young specimens which it has been impossible to define. Two large specimens from Punkabari were very well marked. They had relations both with *Gagrella* and *Liobunum* (the marginal projections, for instance, were wanting); but it was impossible to decide whether they were full-grown or not. As their genus was thus dubious, I have not described them.

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#### SUPPLEMENT.

*GAGRELLA SEPIA*, *Loman*.

J. C. C. Loman, (14) 1894, p. 8.

♀. Spine with only few granules at the base. A triangle in front, including the frontal eminence, is smooth, but beset with a row of three large granules along the frontal margin. Front and back of the high tubercle perpendicular. The top is convex,

provided with a row of rather strong teeth. The transverse row of hairy granules on the ventral segments wanting.

♂. Four frontal granules, not placed in a single row. A small tubercle on the first abdominal segment before the spine. Tarsi of the palps with the usual row of teeth.

In all other respects this species is similar to *G. sepia*, Lom., and as it was taken by Loman at the same locality, it must be regarded as the same species.

*GAGRELLA SPLENDENS*, n. sp.

♂. Cephalothorax almost semicircular. Body raised towards the single spine, sloping gradually behind. It is granular, with dense and low granules above, the coxæ bearing a few larger granules. Ventral segments smooth. Frontal eminence well marked. Lamina frontalis distinct, broad, and merging on each side into the small but stout procursus frontales.

Tubercle, seen from the side, rather low, convex, and as high in front as behind. Seen from the side, broad and scarcely narrower towards its base. It is granular on both sides of the groove. Diameter of the eyes larger than the distance between their lower edge and the base of the tubercle, and smaller than the distance between them.

Basal joint of antennæ smooth. Procursus max. internus two-branched and pale; branches short, and lower edge beset with a row of granules. Femora of the palps with a few granules below, arranged in an outer and an inner row, and above towards their extremities. Patellæ short, thinner at their bases, and beset with a few granules. Tibiæ longer than the patellæ, twice as long as broad, cylindrical, and very thick—as thick as the femora (compare the male of *G. ænescens*). They are somewhat thinner towards their extremities and base, and a little convex below; underneath they are hairy with long stiff hairs, and above only with short. The tibiæ are only a little longer than the patellæ. Tarsi hairy and much thinner than the tibiæ, with a row of comparatively few teeth, of which the 13 proximal are placed near to each other from the base to the middle, and the 4 distal are widely separated.

Femora of the legs toothed. Tibiæ II have false articulations.

F. I =  $11\frac{1}{2}$  (42), II =  $17\frac{1}{2}$  (80), III =  $10\frac{1}{2}$  (41), IV = 15 (60). Second joint of the antenna  $1\frac{1}{2}$  mm. long. Body 5 mm.

Colour black above, with a beautiful metallic gloss. Between

the tubercle and the front a longitudinal yellow band, broader behind, and including a black pointed spot, starting from the front, the point being turned backwards. Near the margin of the cephalothorax are other yellow spots. Along the margins of the scutum there are three such spots on each side. Coxæ yellowish-brown, with darker spots. Free ventral segments yellowish, with darker spots. Legs brown, with the trochanters, patellæ, and tibiæ black. Antennæ and palps yellow. Yellow spots larger in another specimen, and the hinder margins of the free dorsal segments are yellow.

Mr. Schönau has taken two males at Woosung (China?).

This species is similar to *G. ænescens*, Thor., but the colour is very different and the legs are stronger.

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POSTSCRIPT.—In a paper published in 1901, E. Simon has described one new genus and in all seven new species of *Gagrellinae* from the Malay Peninsula, viz.: *Gagrella bicornigera*, *G. semigranosa*, *G. patalungensis*, *G. illusa*, *G. biseriata*, *G. atrorubra*, and *Verpulus spumatus*. They seem all to be well defined from those established by myself. Simon's paper (21) was unfortunately overlooked when I was engaged on the present treatise, and his species have not been taken into account in the synoptic keys. The last-named paper of Loman (22) was published after I had sent in the manuscript; his species have been inserted in the list (pp. 466-68) on the geographical distribution together with those of Simon (21), when I looked over the proof.

C. WITT.

21st February, 1903.





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